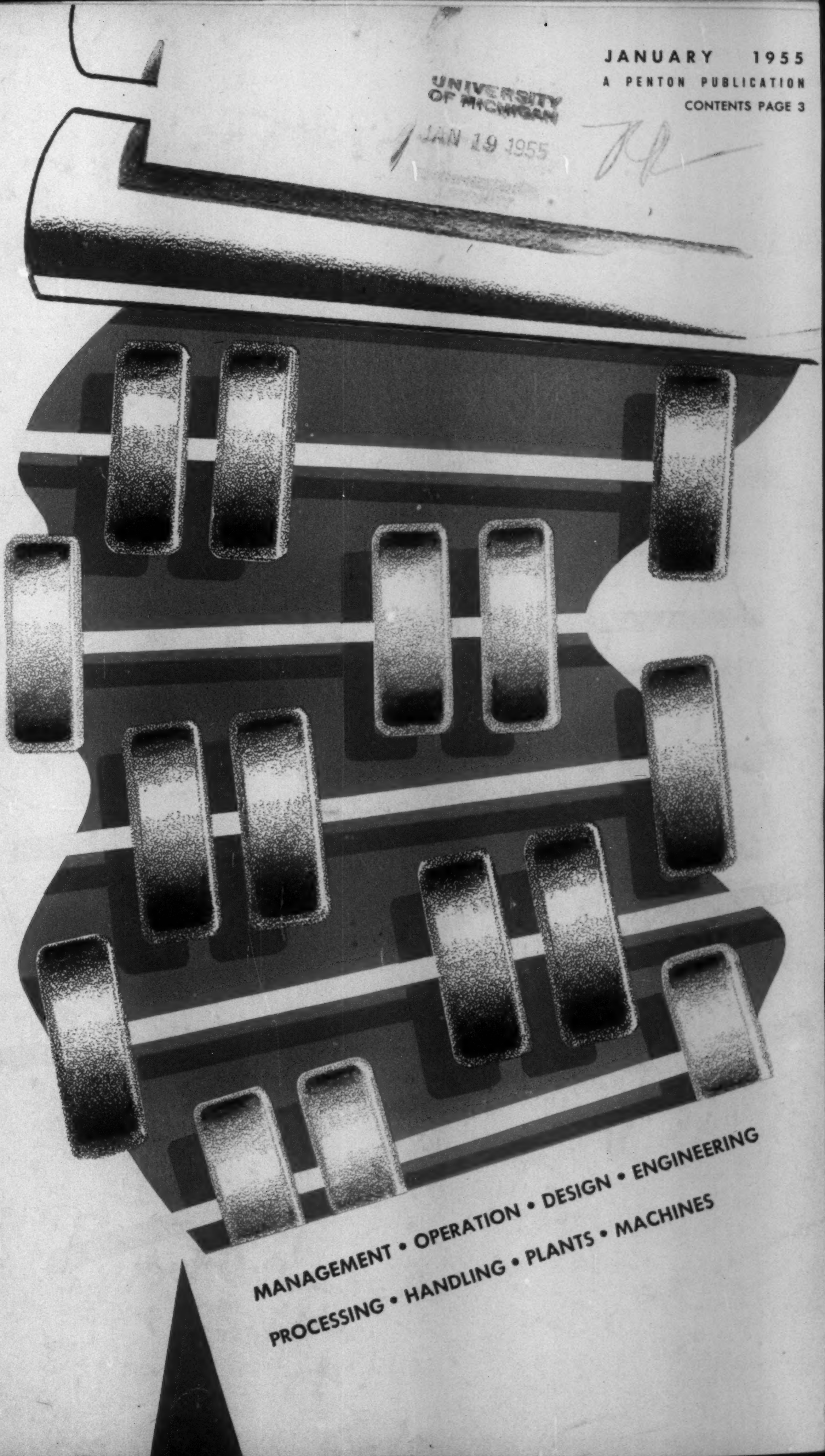
AUTOMATION

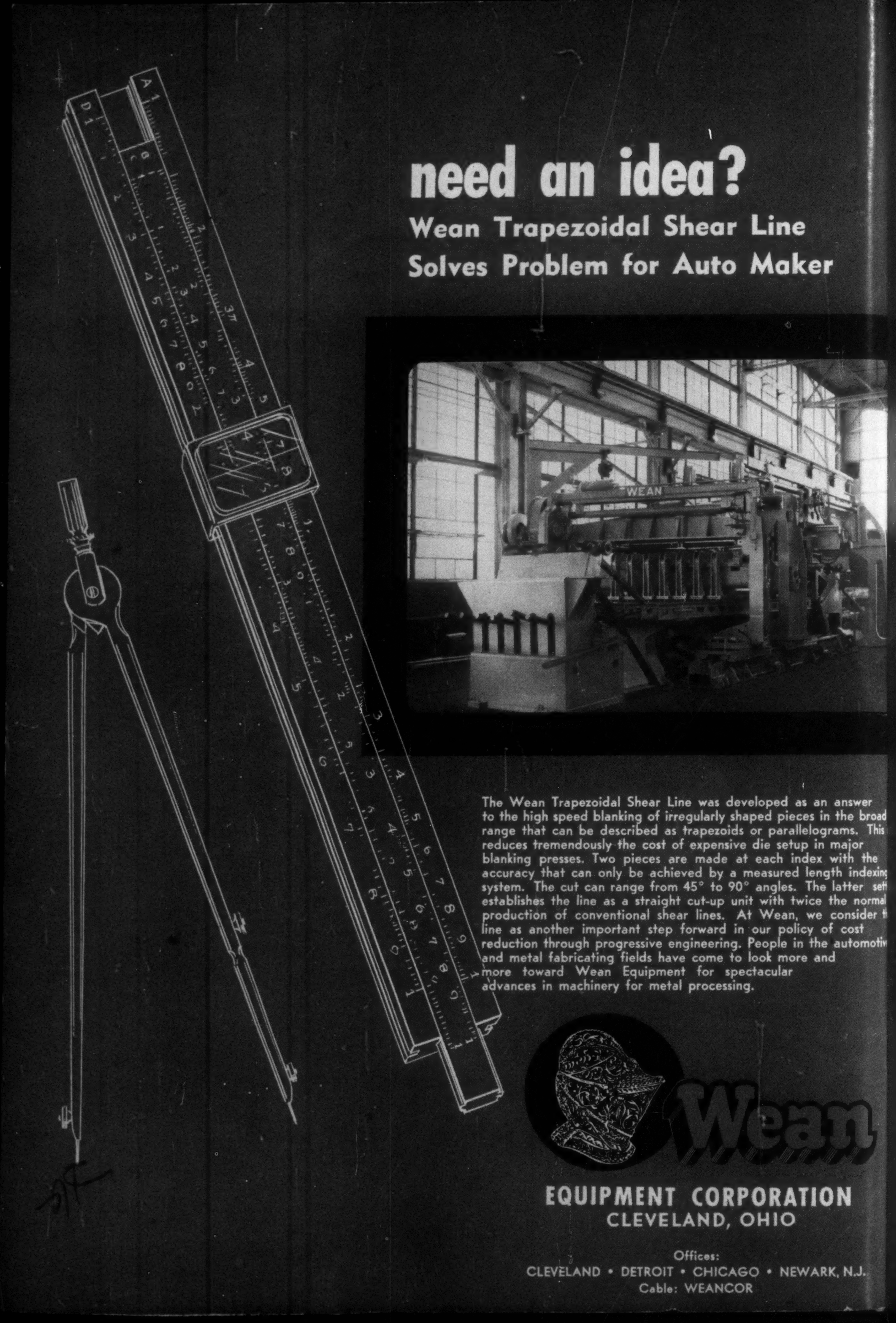
JANUARY 1955
A PENTON PUBLICATION

CONTENTS PAGE 3

UNIVERSITY OF MICHIGAN
JAN 19 1955



MANAGEMENT • OPERATION • DESIGN • ENGINEERING
PROCESSING • HANDLING • PLANTS • MACHINES



need an idea?

Wean Trapezoidal Shear Line Solves Problem for Auto Maker

The Wean Trapezoidal Shear Line was developed as an answer to the high speed blanking of irregularly shaped pieces in the broad range that can be described as trapezoids or parallelograms. This reduces tremendously the cost of expensive die setup in major blanking presses. Two pieces are made at each index with the accuracy that can only be achieved by a measured length indexin system. The cut can range from 45° to 90° angles. The latter sett establishes the line as a straight cut-up unit with twice the normal production of conventional shear lines. At Wean, we consider t line as another important step forward in our policy of cost reduction through progressive engineering. People in the automotiv and metal fabricating fields have come to look more and more toward Wean Equipment for spectacular advances in machinery for metal processing.

Wean

EQUIPMENT CORPORATION
CLEVELAND, OHIO

Offices:
CLEVELAND • DETROIT • CHICAGO • NEWARK, N.J.
Cable: WEANCOR

Engin
[illegible]
1-12-55
90086
Vol 2, no. 1-

JANUARY, 1955
Vol. 2—No. 1

AUTOMATION

THE MAGAZINE OF AUTOMATIC OPERATIONS

EDITORIAL STAFF

ROGER W. BOLZ, Editor
JAMES C. KEEBLER, Associate Editor
WILBUR R. ELLIS, Assistant Editor
STANLEY B. STEWART, Assistant Editor
FLEUR E. WOODS, Assistant Editor
HELEN M. VERESPY, Editorial Assistant

WILLIAM G. KELLOGG, Art Director

Editorial Representative

NORMAN LYNN
Los Angeles, Webster 5-3040

REGULAR DEPARTMENTS

Automation Outlook, 4
Automation News, 9
New Equipment, 72
New Components, 88
Abstracts, 102
Patents, 110
Editorial Index, 112
New Books, 114
New Literature, 117

Indispensable Judgment, 21
EDITORIAL—under continuously changing conditions computers can only aid, not replace, men's judgment.

Automatic Machines Make Hand-Dipped Candles, 22
CARL J. SCHROEDER—techniques of automation used to make improved product at lower cost.

High-Speed Paper Coating, 34
AUTOMATION TODAY—huge rolls of paper are unwound, coated and rewound automatically.

Automatic Boring, 38
NEW TOOLING METHOD—holds precision tolerances of valve holes in cylinder heads.

Integrated Data Processing, 39
P. B. GARROTT—part two—illustrative forms show concept that makes the paperwork process automatic.

Diode Amplifiers, 45
ELECTRONIC COMPONENTS—semiconducting devices have characteristics useful in high frequency circuitry.

Automatic Control Terminology, 49
ADJUSTMENTS OF CONTROLLER ACTION—standard process control terms defined and illustrated.

Machining Shells, 50
NEW DEVELOPMENT—simplified automatic workpiece handling increases turret lathe production.

Automatic Lubrication Cuts Costs, 52
CENTRALIZED SYSTEM—reduces maintenance costs and downtime in coal preparation plant.

Automatic Gaging For Cyclic Processing, 55
ALBERT C. SANFORD—part two—in-feed grinder applications illustrate type of machine control.

Hydraulic and Pneumatic Servos, 61
R. HADEKEL—part four—analysis of flow control considerations in servo valves and pumps.

Timer Sequences Vacuum Metallizer, 70
ELECTRICAL CYCLING—makes laboratory technique into television tube production process.

AUTOMATION OUTLOOK

KEEP COSTS DOWN

". . . a high percentage of rejects and complaints from critical customers were also in evidence. This, in addition to business competition in a field of high labor costs and slender margin of profit, forced consideration of automation or else! The problem was resolved into a need for a product of better quality and appearance, uniformity in shape and size, and lower cost. A careful study revealed that a substantial amount of existing equipment could be utilized which, with some modifications, could be worked into the new installation to help keep costs down . . ." —*Carl J. Schroeder, staff engineer, Standard Oil Company of Indiana. See Page 22.*

AND ADDED IMPORTANCE

". . . The worker will be more important than ever in the age of the 'pushbutton' factory. As the working force becomes relatively smaller in proportion to output, the worker himself becomes not less but more important. Increased investment in machines multiplies the need for wise, uninterrupted, and cooperative use of them. Automation offers 'a wealth of ingenuity,' but it does not decrease the need for good human relations in industry; in fact, it tends to magnify the human problem because it still further separates the man from his ultimate product, thus diminishing the spirit of craftsmanship and the sense of accomplishment . . ."—*Paul D. Arnold, president, Arnold Bakers Inc.*

MUCH MORE COMPLEX

" . . . When the product to be manufactured is three dimensional or discrete and therefore not susceptible to flow, the problems of materials movement and placement are much more complex because a much higher degree of precision is usually necessary than in the case of bulk materials. Consequently, the accomplishment of automation in the manufacture of such products involves the design, manufacture, installation, operation, control and maintenance of much more complex assemblages of integrated, power-driven, materials movement, materials processing and process control equipment . . ."—*Harold W. Martin, associate professor, management engineering, Rensselaer Polytechnic Institute.*

STEP BY STEP

". . . these advances in the business, banking, merchandising and manufacturing areas will not come as an avalanche. There will be no revolution but rather a hard earned step-by-step evolution. Just as there has been steady progress over the past decades in mechanization of operations in business and manufacture, so will there be progress in the coming decades in the applications of electronic automation through digital systems. We are indeed at the threshold of an interesting, exciting and economically worthwhile development for business and industry . . ."—*Mervin J. Kelly, president, Bell Telephone Laboratories.*

CHANGING TIMES

". . . the ratio of the U. S. labor force to the total population will be about 14 per cent less by 1963, causing a shortage of labor and accenting the need for both industrial and agricultural mechanization. Total population will reach about 177 million by 1963 but this group will be mainly of 14 to 17 year age—about 50 per cent higher than today . . ."—*Steven P. J. Wood, president, Warner Electric Brake & Clutch Co.*

LOWER COST, MORE EMPLOYMENT

". . . printed chassis assembled by automation has made possible for the first time a TV set utilizing a giant aluminized 21-inch, 90-degree tube with a 27-square inch picture and a full 18-tube vertical chassis for only $149.95. And rather than displacing personnel, production increase has made it necessary to hire more employees to complete final hand assembly . . ."—*John B. Huarisa, executive vice president, Admiral Corp.*

AUTOMATION

Penton Building, Cleveland 13, Ohio
Main 1-8260

BUSINESS STAFF

EDWARD S. LAWSON
Business Manager

J. M. Castiglione, *Production Manager*

George J. Auner, *Statistician*

Lois Gartman, *Staff Assistant*

Advertising Representatives

New York 17 . . . . 60 East 42nd St.
Robert G. Macbeth
Murray Hill 2-2581

Cleveland 13 . . . . Penton Building
Larry D. Brennan
Gordon W. Rosencrans, Jr.
Main 1-8260

Chicago 11 . . . . 520 North Michigan Ave.
Richard K. Lotz
Richard W. Jones
Whitehall 4-1234

Los Angeles 57 . . . . 2330 West Third St.
The Robert W. Walker Co.
Dunkirk 7-4388

San Francisco 4 . . . . 57 Post St.
The Robert W. Walker Co.
Sutter 1-5568

Griffin, Ga. . . . . 331 South Twelfth St.
Fred J. Allen
Griffin 7854

Circulation

Jack C. Gernhard, Manager
Amy Lombardo, Directory & List Dept.

Published by
THE PENTON PUBLISHING COMPANY

G. O. HAYS . . . . *President and Treasurer*
R. C. JAENKE . . . . *Executive Vice President*
F. G. STEINEBACH . . . . . *Vice Pres. and Secretary*
F. O. RICE . . . . *Vice President*
J. P. LIPKA . . . . *Asst. Secy. and Asst. Treas.*

Also Publisher of
STEEL • FOUNDRY • MACHINE DESIGN
NEW EQUIPMENT DIGEST

Published monthly. Subscription in the United States, possessions, and Canada: One year $10. Single copies, $1.00. Other countries one year, $20. Copyright 1954 by The Penton Publishing Company. Accepted as Controlled Circulation Publication at Cleveland, Ohio.

AUTOMATION NEWS

Today's events and developments of importance in the field of modern automation

Electronic Computer Changes Pilots' Firing Technique

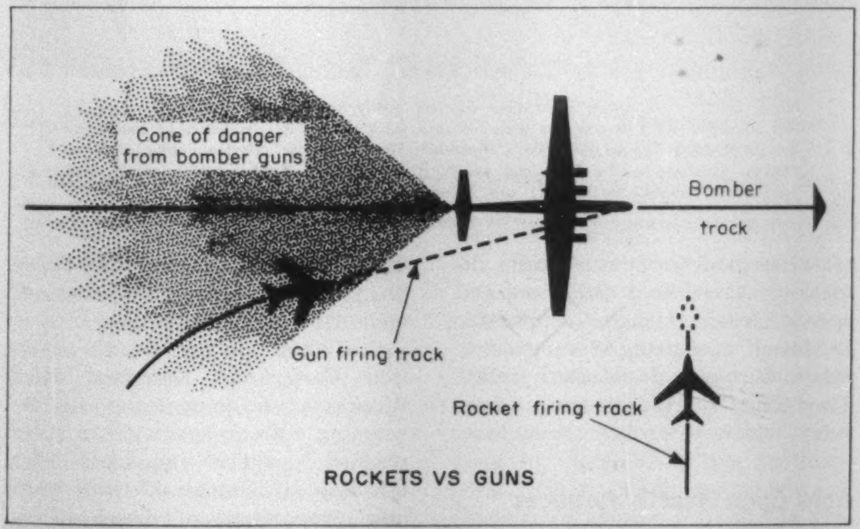
U. S. AIR FORCES' Air Defense Command has revealed how electronics has changed the fighter pilot's marksmanship in the business of destroying a well defended enemy bomber.

Marksman no longer bores in with guns blazing, using the enemy's fuselage insignia as a bullseye. Now he sees a blue-green "blip", a weaving pin point on the radar scope. If pilot is successful in keeping this point in a small reference circle until an automatic computing machine lowers his rocket pod and fires, he will hit the bullseye.

In previous firing methods, fixed guns had to be trained on target for a considerable amount of time in order to produce sufficient firepower to bring a victim down. To accomplish this, fighter pilot was continuously aimed slightly ahead of his target. This made him fly a curved course, a "lead pursuit curve." While this system is effective against other fighters or lightly defended bombers, the cone of fire from tail guns of a heavily defended bomber reduces the fighter's probability of survival.

Now a rocket-firing interceptor, armed with a computing machine to fire rockets automatically at the precise instant at which they will intercept target, need be on target only an instant. Interceptor flies a straight line collision course until rocket fires. This makes the interceptor practically invulnerable to bomber's defense because bomber's guns must fire into a crosswind at a target whose bearing is changing rapidly. Destructive power of rocket—one will bring down heaviest bomber known to be flying today—is a second great advantage over guns. Rockets fire a shot gun pattern and one of these will bring a victim down.

Rocket used is the 2.75 "Mighty Mouse", a Navy development which went hand-in-hand with development and manufacture of the F-86D Sabre Jet interceptor and Hughes Aircraft Co.'s fire control system. The "Mouse" packs punch of a 75 mm cannon and travels to its target at a speed exceeding 2,000 mph.



FIGHTER making a pass with guns at a well defended bomber must enter the deadly cone of fire from the enemy's tail guns (left). With rockets fired electronically, fighter (right) makes a side approach, forcing the bomber to defend itself in crosswind on a target rapidly changing its angle of approach as it closes in. Rocket used is Navy's "Mighty Mouse" which was developed for the F-86D Sabre Jet Interceptor.

Rubber Railroad

POTASH MINE in Carlsbad, N.M., will soon be equipped with one of the longest conveyor systems in the United States.

Designer and builder of conveyors, Hewitt-Robins, Inc. has been awarded a contract by the Potash Co. of America, owner of the mine, to extend the present underground conveyor system to a total length of approximately 7¼-miles.

Present Carlsbad conveyor system, installed by Hewitt-Robins in 1952, is 5,800 feet long. The expansion program calls for additional units totaling 32,320 feet, which will increase the combined length to 38,120 feet.

"Rubber railroad" will operate 1,000 feet underground in a potash ore seam about 4 feet thick. Continuous mining machines will extract the potash ore from the working face of the mine and deposit it on shuttle type conveyors known as Mine-aveyors, which automatically transfer it by intermediate belts to the main line or "mother" belts. From there the potash will be carried more than five miles to a 3,000-ton underground storage pocket from which it will be withdrawn as needed by a special rotary plow feeder and be delivered to a vertical skip hoist by additional belt conveyors. Conveyor system, when completed late in 1955, will consist of 45 units linked together to carry the material in a continuous flow from the mining area to the refinery.

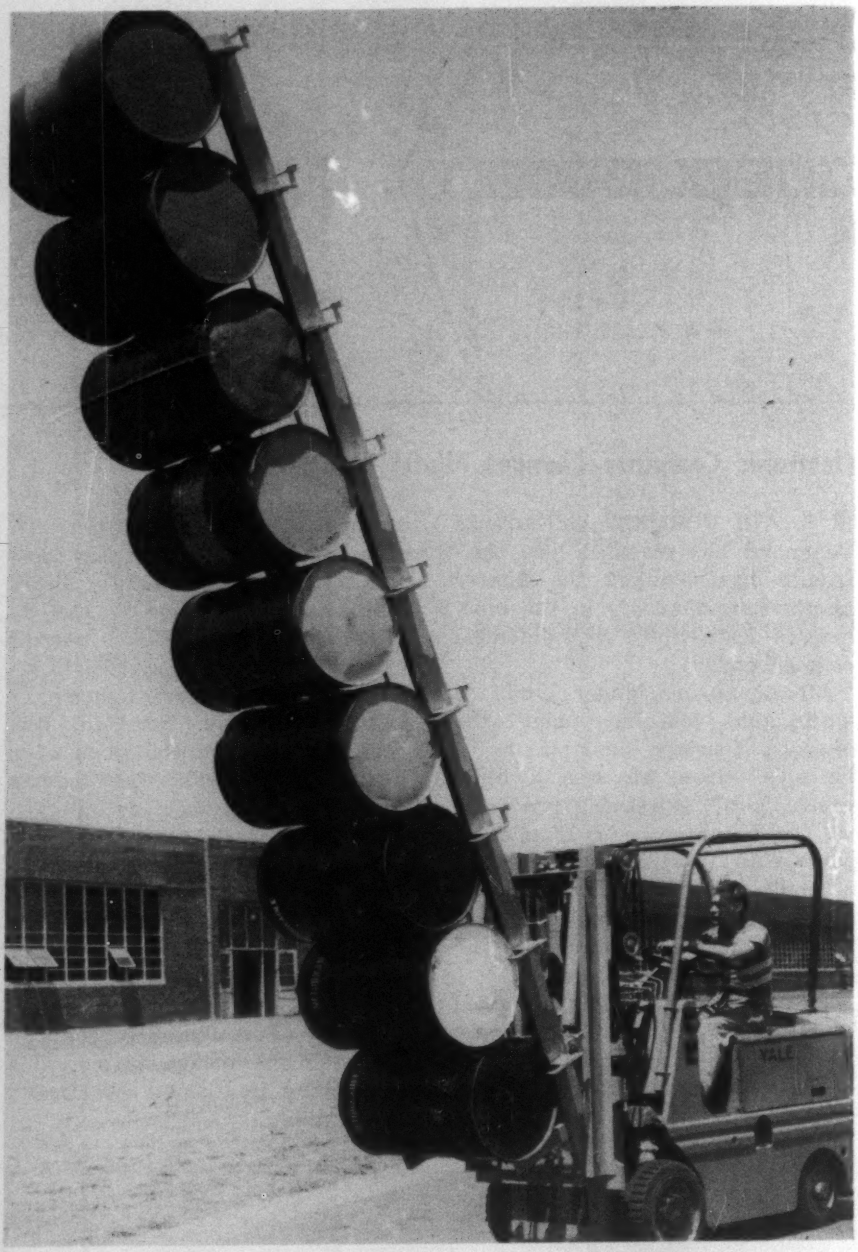
Affiliation Agreement

MANUFACTURER of process control, data reduction and information systems, Panellit Inc., recently announced an affiliation agreement with Taller & Cooper, manufacturers of scientific equipment. By combining the companies' manufacturing and engineering facilities, Panellit will be able to cover a wide range of data reduction and automatic process logging. New Tal-Cooper Div. of Panellit Inc. will handle marketing and application engineering of Taller & Cooper products employed in the rapidly expanding data reduction field and will continue to manufacture and distribute toll collection equipment under their own name.

Air Pollution Regulated

IMPORTANT FACTOR in economy and efficiency for new devices developed by Friez Instrument Div. of Bendix Aviation Corp. is automatic control feature of equipment to regulate industrial air pollution.

Windtrol unit will activate equipment only when wind speed and direction result in an objectionable pollution situation. Device is similar to a windvane equipped with a propeller. Wind speed is measured by rotation of a propeller coupled to a magnet. Drag of the magnet on a calibrated, spring-restrained cup indicates speed. Commutator and brush serve to measure angular displacement equivalent to selected speeds. A similar commutator, constructed with silver segment contacts, is used to measure wind direction. At selected directions and speeds circuit through transmitter is closed, energizing a time delay relay, through a sensitive relay. Time delay relay operates a power relay which controls desired load.



NINE EMPTY OIL drums at a time can be easily carried and quickly stacked by this standard 4000 lb capacity gasoline fork truck with a new attachment developed by the Yale & Towne Mfg. Co.'s Materials Handling Div. Hydraulically actuated clamps, located on the 224 inch boom, grab all nine drums simultaneously and hold them securely while they are being transported and stacked.

Acid Open Hearth Furnaces

HIGH GRADE steels produced in acid open hearth furnaces cannot tolerate sulfur absorption from high sulfur Bunker C (No. 6) fuel oil. In addition uniform flame characteristics are desirable to provide uniform heating of melt.

Cincinnati Div. of Bendix Aviation Corp. and Standard Steel Works have co-operated in developing a fresh approach to these problems which includes: (1) blending of Bunker C with suitable proportions of diesel oil by means of Bendix Ultra-Viscosor electronic viscometer to reduce the sulfur content of charge fuel, and yet maintain uniform viscosity and BTU content; (2) using this more expensive fuel blend only until the slag forms on top of the melt, protecting it from sulfur absorption, then use only Bunker C; (3) regulating the fuel atomization operation by maintaining viscosity of fuel oil at an optimum value through continuous control of steam flow to fuel oil preheater by means of another Bendix Ultra-Viscoson control system. Uniform flame characteristics are thereby achieved.

It is claimed that adoption of these systems has resulted in savings in terms of overall reduction in heat time, lowering of furnace maintenance and fuel costs.

Expansion Spans Ocean

MANUFACTURERS of electro-optical instruments, astronomical telescopes, special cameras, etc., Perkin-Elmer Corp. has purchased control of an optical and aircraft testing plant in Germany. Company is Bodenseewerk, of Uberlingen/Bodensee, Germany—a location near the Swiss border.

Built in 1949, the German optical plant covers 14,000 square feet and employs over 200 persons. Bodenseewerk has produced military instruments for British Ministry of Supply, and French and American Governments. In addition to equipment now produced by the German firm, Perkin-Elmer plans ultimately to produce products of its own design at the new facility.

Measuring System

DEVELOPED for industrial use, new electrosyn pressure and temperature measuring systems produced by Norwood Controls Div., Control Engineering Corp. is based on a signal generator which the military has used for some years in servosystems.

Signal generator is a high resolution, electromagnetic, rotary transducer with a linear output. Fluid pressure in a twisted Bourdon tube or a temperature sensitive bimetallic ribbon spiral rotates the signal generator a minute amount, producing a proportional electrical signal. Complete system consists of a constant 60-cycle current source and pressure or temperature detectors which can be directly mounted on a vessel or pipe line without additional support. Electrosyn system facilitates remote readings of temperature and pressures without complex electronic circuits.

Newcomer to Automation

ORGANIZED recently, Automation Associates is performing services pertinent to printed wiring and mechanized assembly in the electrical and electronic industry. To date, the organization has performed market and technical surveys, drafting, and printed circuit product development. Special projects include development of satisfactory materials and methods for new and improved printed circuits and printed wiring; establishment of printed circuit production facilities for various clients; and working with machine manufacturers in developing suitable equipment for assembling components to printed wiring board. **Mr. John A. Zagusta**, formerly chief engineer of Circuitron, Inc. and **Mr. Paul L. Anderson**, formerly sales manager and production engineer for the same firm head Automation Associates.

Responsible for Co-ordination

IN HIS NEW post as assistant manager for Servomechanisms Inc., **Mr. Joseph A. Kuzman** will be responsible for co-ordinating engineering and production functions with the overall sales program of the company's Westbury division.

For two years prior to this appointment, Mr. Kuzman was chief production engineer. He joined the organization in 1950. Kuzman is a

Automation Statistics

AUTOMATION—a word until recently considered by many as too fancy for practical use—has attained acceptance in the lexicon of industry.

A survey conducted among engineers, technicians and industrial executives in 10 major industry groups for Minneapolis-Honeywell's Industrial Division found automation was the favored word of 82 per cent of those questioned when they sought to describe automatically controlled operations.

Automation, they agreed, signifies "the automatic performance of a controlling function by mechanisms instead of men. This automatic control is obtained through measuring and correcting variables by instruments and mechanisms, with no human intervention" (except, of course, to map the primary course and when things go wrong). "It is not peculiar to any specific industry."

Objective of the special survey was to determine the general attitude among technical men and executives toward automation, its significance and meaning and to discover, as well, variations in its definition. The study covered more than 400 industrialists, diversified as to industry and geographic area.

According to the survey, automation embraces automatic handling of materials; control of temperature, pressure and velocity; automatic processing; assembly of parts; measurement of variables; operation of aircraft, missiles; receiving, storing and shipping functions; computing and data handling; control of household devices and cost accounting.

The study also revealed that most of the engineers and technicians do not consider "control" to be a part of instrumentation. (The term instrumentation has long been preferred by industrial engineers as a word descriptive of measuring and controlling instruments.) In their opinion, automation is the whole of which instrumentation is but a part.

member of ASME and Operations Research Society of America.

Mobile Color Sorting

DESIGNED for automatic sorting of seed peas and beans, new portable electric color sorting system consists of 12 photoelectric sorting machines mounted in a 35-foot trailer. Unit, which has own power supplies and other auxiliary equipment, is a product of Electric Sorting Machine Co.

Mobile unit permits photoelectric sorting of seeds and has been developed in response to the demand for mobile equipment which, by following harvesting operations wherever they occur, can apply photoelectric sorting procedures to seed products directly "in the field." Trailer, in which sorting machines are housed, is manufactured by Trailmobile Co.

Transistor Firm Created

FORMED recently, General Transistor Corp., an organization created to engineer and manufacture transistors and related semiconductor products announced that **Mr. Eugene Kral** has been named president; **Mr. Herman Fialkov**, vice president.

Mr. Kral was formerly with Eugene Kral & Co. manufacturers of quartz crystals. His many years experience with quartz, processing of which is similar to that of germanium in some respects, has been the key factor in enabling the company to develop wafer surfacing techniques which assure transistors with low noise characteristics.

Mr. Fialkov, formerly chief engineer of the Germanium Div. of Radio Receptor Co. is a graduate of the College of Engineering of New York University and has 13 years experience in the electronics field.

Looking to the Future

FORMATION of an Electronics Div. by Seneca Falls Machine Co. was announced today by **Edwin R. Smith,** president of the machine tool manufacturing concern. Pointing out that his company has for some time been experimenting with electronics and has made considerable progress, Mr. Smith said that it would seem that the time has now arrived, "when any machine tool builder who intends to be in a competitive position in the future should devote some of his time, energy and money to the development and application of electronics."

Robert H. Eisengrein has been appointed director of the new division. Mr. Eisengrein holds a bachelor of electrical engineering degree from Brooklyn Polytechnic Institute and a master of science degree in electrical engineering from Massachusetts Institute of Technology. He comes to Seneca Falls from Sundstrand Aviation where he was chief research engineer.

"All-Transistor" Calculator

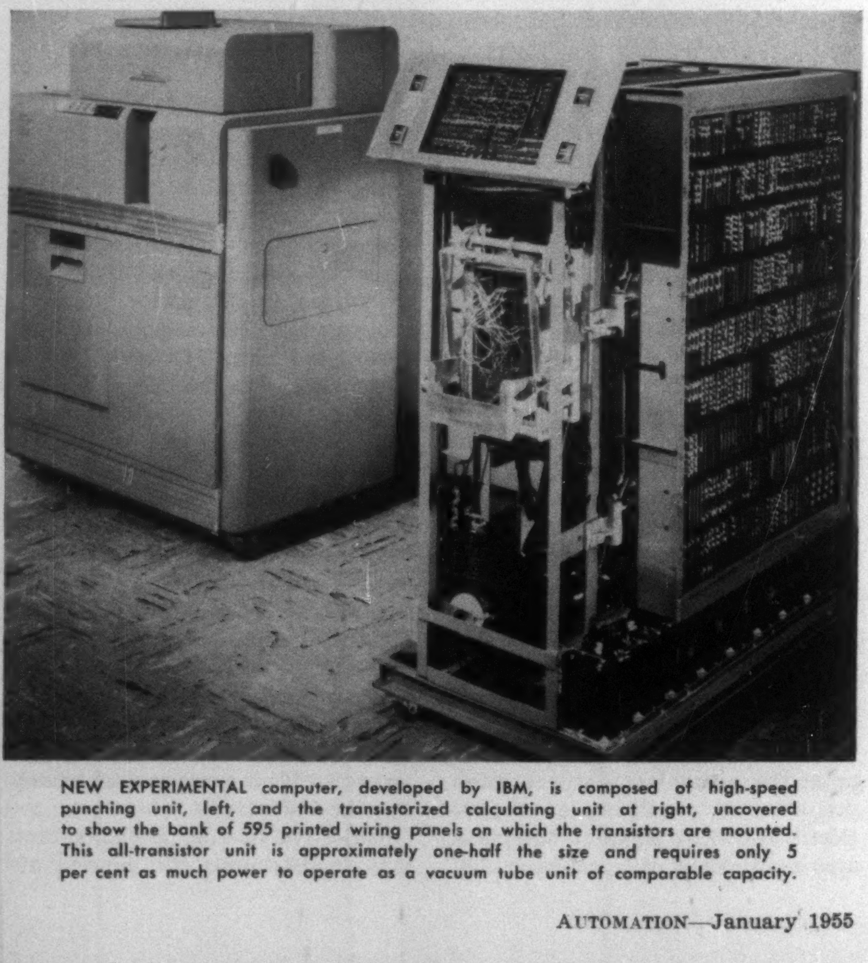
EXPERIMENTAL, all-transistor, calculator with a computing unit about one-half the size and requiring only 5 per cent as much power as a comparable vacuum tube unit was demonstrated recently at IBM's new Poughkeepsie, N. Y. research and development laboratory.

In presenting the calculator for its first public demonstration, **W. W. McDowell,** vice president in charge of research and engineering, pointed out that it is an experimental machine.

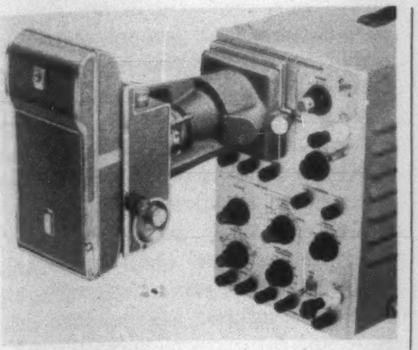
New unit is comparable in capacity to IBM's type 604 electronic calculator that uses 1,250 vacuum tubes. While speeds are similar, shown side-by-side the two machines provided a sharp contrast in size. This experimental engineering model is believed to be the first fully-operated transistorized computer complete with automatic input and output. More than 2200 transistors are used in the machine. A number of these are of a design developed by the company's own engineers to meet the operating characteristics required in computer circuits.

In addition to reducing the size of the machine, transistors effect a 95 per cent reduction in power requirements of the electronic unit, eliminating need for a bulky power supply and forced air cooling of components.

Because transistors have a much longer life than vacuum tubes, it



NEW EXPERIMENTAL computer, developed by IBM, is composed of high-speed punching unit, left, and the transistorized calculating unit at right, uncovered to show the bank of 595 printed wiring panels on which the transistors are mounted. This all-transistor unit is approximately one-half the size and requires only 5 per cent as much power to operate as a vacuum tube unit of comparable capacity.



FULLY AUTOMATIC oscilloscope camera, of special configuration and based on an adaptation of the Polaroid fast-print principle, has been developed by Aremac Associates. New Recordoscope provides an accurate and permanent photographic documentation of cathode-ray tube phenomena 60 seconds after exposure of scope image. Camera delivers finished black field prints in 60 seconds or less. Fully automatic magazine-shifting mechanism records 3 to 16 traces per 3 by 4-inch print.

is expected that necessary maintenance of machines employing them will be significantly reduced from that of vacuum tube machines.

Printed wiring, replacing much of the wiring normally comprising a computer's nervous system, was incorporated into the design of the new calculator to simplify production and maintenance, and greatly reduce space requirements. The model contains 595 printed wiring panels, on which transistors are mounted. Each panel is about two-thirds the size of an IBM card.

Sales Manager

FORMERLY sales manager of Process Machinery Div. of Cincinnati Milling Machine Co., **Kenneth P. Martin** has been appointed general sales manager of National Automatic Tool Co. Inc. Mr. Martin was part owner and general manager of Hydroform Corp. and developed the machine of that name.

Remote Weight Control System

COMPONENT parts of a new remote weight-control system for continuously and accurately blending additives with process material are: an electric control system, automatic hopper scale, control panel and a constant-weight belt feeder.

Products handled include chemi-

MAGNETIC AMPLIFIERS
632 TINTON AVENUE INC
NEW YORK 55, N.Y.
MAGNETIC AMPLIFIER
MODEL NO
SERIAL NO
115 VOLTS 60 or 400 cps.
INPUT NO. 1
INPUT NO. 2

NEW! MINIATURE SERVO Magnetic Amplifiers

Three New AC Servo Types Available..

STANDARDIZED SERVO SYSTEMS AND OTHER STANDARD TYPES FOR AUTOMATIC CONTROL —

In addition to new lines illustrated, many standard and higher power magnetic amplifiers are available for applications involving automatic control.

CUSTOM DESIGNS FOR SPECIAL REQUIREMENTS

— we design and engineer complete servo or automatic control systems

- MAGNETIC PRE-AMP + SATURABLE TRANSFORMERS
  Supply: 115 volt 400 cps.
  Power output: 3.5, 6, 10, 18 watts
  Sensitivity: 1 volt AC
  Response Time: .03 sec.
  Lowest Cost — Smallest Size
  For further information request Form S493
- MAGNETIC PRE-AMP + HIGH GAIN MAGNETIC AMPLIFIER
  Supply: 115 volt 400 cps.
  Power output: 5, 10, 15, 20 watts
  Sensitivity: .1 volt AC
  Response Time: .008 to .1 sec.
  Highest performance — All magnetic
  For further information request Form S496
- TRANSI-MAG*: TRANSISTOR + HIGH GAIN MAGNETIC AMPLIFIER
  Supply: 115 volt 400 or 60 cps.
  Power output: 2, 5, 10, 15, 20 watts
  Sensitivity: .08 volt AC into 10,000 ohms
  Response Time: .01 sec.
  Fast response at high gain
  For further information request Form S499 (400 cps.); Form S497 (60 cps.)

*TRADE NAME

AFFILIATE OF THE GENERAL CERAMICS CORPORATION

MAGNETIC AMPLIFIERS • INC
Telephone: CYpress 2-6610
632 TINTON AVE., NEW YORK 55, N. Y.

AUTOMATION is a 20 YEAR OLD FACT

at

PRATT & WHITNEY

The *name*, perhaps, is new, but AUTOMATION . . . with "feedback" control and automatic adjustment . . . has long been a practical working *fact* at Pratt & Whitney. Nearly 20 years ago, for example, P&W Syncro-Timer Control Units, operating in conjunction with P&W Continuous Gages, were successfully applied to the completely automatic classifying and sorting of tin plate on shearing lines. P&W Gages and Control Units that automatically correct the thickness of coating insulation on extruded wire went into operation 8 years ago.

TODAY we are successfully applying the same basic principles to automatically control the screwdowns on tandem and reversing cold strip mills to insure uniformity of product.

No . . . you don't have to wait for ***automation*** to happen. Its opportunities for added efficiency, improved product quality and lower costs are available ***RIGHT NOW*** via Pratt & Whitney. Installations are compact, simple and inexpensive. Take advantage of our wide experience. Call in the Pratt & Whitney Specialist now. There is no obligation.

PRATT & WHITNEY
DIVISION NILES-BEMENT-POND COMPANY
WEST HARTFORD 1, CONNECTICUT, U. S. A.
SINCE 1860

First Choice for Accuracy

BRANCH OFFICES AND STOCK • BIRMINGHAM • BOSTON • CHICAGO
CINCINNATI • CLEVELAND • DALLAS (The Stanco Co.) • DETROIT • LOS ANGELES
HOUSTON (The Stanco Co.) • NEW YORK • PHILADELPHIA • PITTSBURGH
ROCHESTER • SAN FRANCISCO • ST. LOUIS • EXPORT DEPT., WEST HARTFORD

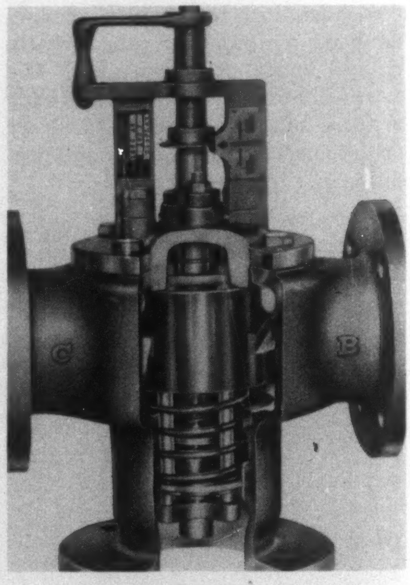
MACHINE TOOLS • CUTTING TOOLS • GAGES

cals, foods, feeds, fertilizers, tobaccos, plastics, and cement and rock products. Developed by Richardson Scale Co., system batch-weighs additives, continuously weighs process material, and features remote selection of weight ratios using a single dial control.

In operation, process material drops on a belt feeder and discharges into a mixer. Batches of additive material are weighed and automatically discharged into same mixer. Signal for additives discharge is transmitted by an impulser on the belt feeder. Flow of material leaving the belt feeder determines discharge rate.

Future of Computers Discussed

NEW MACHINES and new methods for increasing clerical productivity were featured at AMA's Annual Office Management Conference. Over 1000 office executives attended the three-day meeting at Hotel Astor, New York. Program which was under the direction of AMA Vice President **Herman**



CUTAWAY VIEW of new temperature regulator reveals poppet valve (center, in cold position), which is pulled downward as temperature increases and expands Power-Pill element. Unit is positioned inside spring at bottom. Water or lubricating oil flows up through bottom opening and is diverted through by-pass connection "B" or through cooler connection "C". The hand crank is used to over-ride automatic action or for emergency manual control. Temperature regulator is a new product of Fulton Sylphon Div., Robertshaw-Fulton Controls Co.

Knauss, planning director, Mutual Life Insurance Co., devoted one entire day to electronic programming and processing including discussions of the impact of computers on office methods and payrolls, programming the computer for clerical production, methods and applications for computers and use of a computer service center. **Mr. W. W. Smith,** General Electric Co., highlighted the opening session in his speech, "Impact of the Computer on Methods."

Other sessions discussed office cost reduction, work simplification training, office service to sales management and planning of new office space.

Assembly Process Simplified

DEVELOPMENT OF equipment and a new technique by Bruno-New York Industries Corp. improves assembly process for resistors, capacitors, diodes and other axial lead components as well as sleeved or bare wire jumpers. New machine, Pig-Tailor, simultaneously measures, cuts, and bends both axial leads of any component at an average rate of 750 units per hour. Both leads can be cut to any individual length and be bent at any desired point at right angles to the axis, in form of an S or U. Spin-Pin tool eliminates need for long-nose pliers and training and skill required for their use. Tool provides uniform spinning of tailored component leads around turret terminals.

New Model Integrator

DEVICE that mechanically computes metered volume of gases, steam or liquids from orifice meter charts, a new model integrator, has been introduced by Rockwell Mfg. Co.

Electrically operated unit features a counter setback assembly operating from main calibration post that enables operator to run practically all ranges of charts at any base pressure. As a result, range settings are almost infinite in number, as compared with limited number of range holes which could be provided in old style machines. Same setback principle is

AUTOMATIZING?

PRATT & WHITNEY

has the right gage
. . . to do the job better
. . . at the lowest possible cost

IN AUTOMATION, the first vital link in the automatic control chain is the Continuous Gage. But no single gage type is right for all needs. Only Pratt & Whitney . . . offering a ***complete line*** of Continuous Gages . . . is in a position to recommend and furnish the **one** gage type ***exactly right*** for **your** specific job requirements! P&W Continuous Gages include:

NON-CONTACTING ***(Radiation)***

X-RAY GAGES

. . . for strip and foil. Simple to install and maintain. Stability is excellent, unaffected by voltage fluctuations. RANGES: Steel — .001" to .075"; Foil — 0" to .010". FULL SCALE MAGNIFICATION: ± .00025" on Foil; ± .001" on thicker strip.

BETA RAY GAGES

. . . check a wide variety of metals, alloys and non-metallics. Especially well adapted to gaging coated materials when used with a Proportionate Syncronizer. RANGES: Steel — .030" maximum; Other Materials — to 200 ounces per square yard. FULL SCALE MAGNIFICATIONS: to suit job requirements.

CONTACTING ***(Electrolimit)***

MODELS D AND 10-A

. . . continuously indicate thickness variations to .0001" in strip steel and other metals. Combine precise mechanical gaging with electrical magnification. RANGES: to 3/8" thickness by .0001" increments. MAGNIFICATIONS: to suit job requirements.

MODEL B WIDTH GAGE

. . . for narrow strip and flat wire width or round wire diameter. Also used for precision automatic control of coating thicknesses. RANGE: 0" to 2" by .0001" increments. FULL SCALE MAGNIFICATION: ± .005", or to suit job.

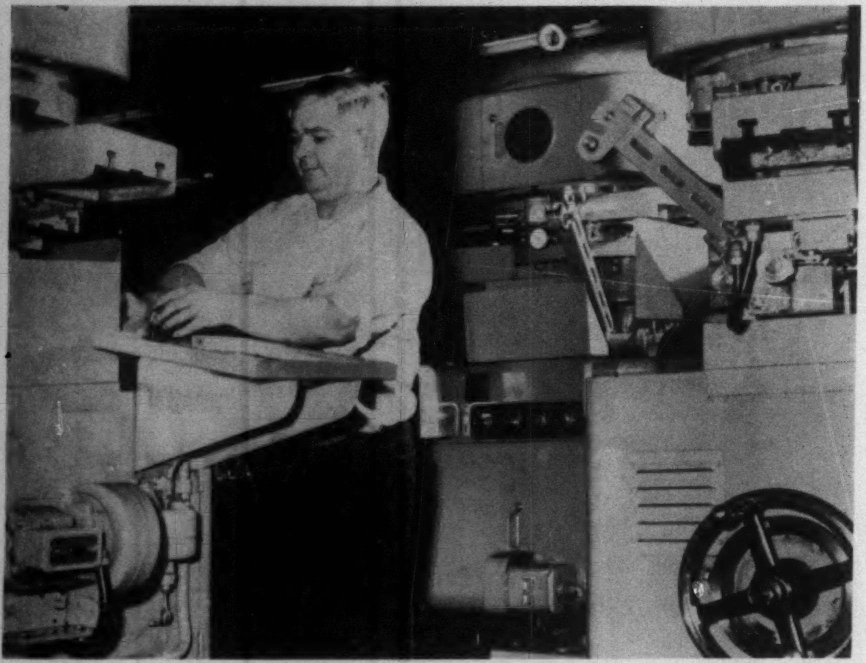
CALL IN THE PRATT & WHITNEY SPECIALIST NOW . . . his broad experience can help you make the most of all the advantages AUTOMATION offers you.

PRATT & WHITNEY
DIVISION NILES-BEMENT-POND COMPANY
WEST HARTFORD 1, CONNECTICUT, U. S. A.
SINCE 1860

First Choice for Accuracy

BRANCH OFFICES AND STOCK BIRMINGHAM* • BOSTON • CHICAGO
CINCINNATI • CLEVELAND • DALLAS (The Stanco Co.) • DETROIT • LOS ANGELES
HOUSTON (The Stanco Co.) • NEW YORK • PHILADELPHIA • PITTSBURGH
ROCHESTER • SAN FRANCISCO • ST. LOUIS • EXPORT DEPT., WEST HARTFORD

MACHINE TOOLS • CUTTING TOOLS • GAGES



SHAVING GEARS, which help insure quiet, smooth operation in automatic transmissions, is done quickly and automatically at Ford Motor Co.'s Automatic Transmission Div., Cincinnati. Operator simply fills automatic loaders and takes away finished gears. One man easily keeps three underpass gear finishers, made by Michigan Tool Co., turning out 600 planet gears per hour. Gears to be shaved are checked automatically for size by a fixture at the entry end of loader and then move down a gravity chute for shaving operation, dropping onto a conveyor when finished.

applied throughout machine, eliminating various separate pen centers and pressure range hole segments. Therefore, when machine is in calibration for one make of orifice meter charts, it is in calibration for all makes of charts that machine will calculate. This simplifies operation and saves operating time by allowing operator to change from chart to chart at will without initiating check runs.

Executive Appointment

VICE PRESIDENT in charge of engineering and manufacturing is **William F. Wilson's** new title with the Gear Grinding Machine Co. Formerly the company's works manager, Mr. Wilson will be in charge of engineering and manufacturing operations for all company divisions, including the new Screw Machine Div.

He came to Gear Grinding Machine Co. from the Walker-Turner Div. of Kearney & Trecker Corp., where he was works manager for 4½ years. Prior to that time, he was with Stevenson, Jordan & Harrison as a consulting engineer for 7 years. He has also been in the Experimental Engineering Dept. of Hudson Motor Car Co.

Wilson holds an engineering degree from Michigan State College and is a member of Engineering Society of Detroit and American Ordnance Association.

Gaging and Classifying Machine

AT 100 PER CENT efficiency, Sheffield Corp.'s latest model automotive cylinder bore gaging and classifying machine can inspect and classify two engine blocks per minute.

Machine simultaneously measures and classifies bore diameters in a six-cylinder engine block, inspects out-of-roundness and taper, and stamps classification of each bore on the block. Bores are divided into ten classes with a 0.0003 difference between each class. Classifying bore diameters in this manner permits selective matching of pistons to bores during assembly.

Six air spindles, each having two diametrically opposed air jets at four positions along its length, are motorized for rapid travel in and out of the block. They explore bores to full depth. Each pair of air jets is connected to a glass column in the 24 column Precisionaire. Floats position instantly—indicate any taper, out-of-roundness, or deviation in diameter. Semiautomatic stamping device mounted above each bore marks bore class on the block opposite each bore.

If a bore tapers too much or contains an obstruction which restricts the upward movement of air spindle, cycle is stopped automatically and a red light indicates faulty bore.

When the spindles are fully extended into bores, a manually operated lever may be used to rotate them simultaneously 180 degrees to check out-of-roundness. Taper is indicated by comparison of four float positions for each of the six cylinder bores.

Low-Cost Computer

TO MEET growing demand for a low-cost easily operated general purpose computer, the National Cash Register Co.'s Electronic Div. has developed a new electronic data processing machine. This computer has the ability to accept data from an electric typewriter, punched paper tape, magnetic tape or punched cards. All data is entered into the machine, operated on, and printed out in decimal form. New high-speed paper tape reader, capable of reading 200 characters per second, and a new paper tape punch with a punching speed of 60 characters per second, are also available. These devices greatly reduce machine filling time and change-over time.

Overhead Sand Handling System

MECHANIZED producer of bronze castings for industrial and automotive bushings, Superior Brass Works, Inc. has just completed installation of an automatic overhead sand handling system for its bronze foundry.

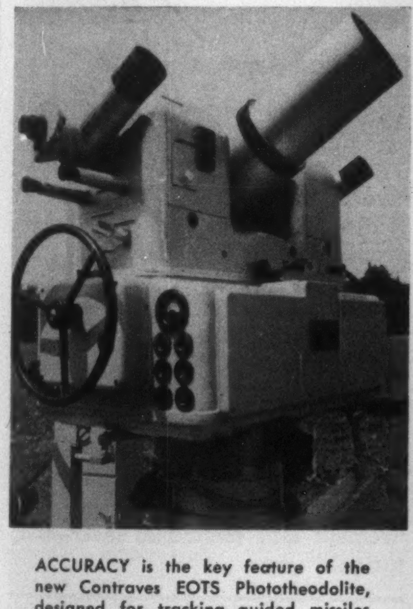
One feature of installation is that mechanized facilities are for only six molders. Rule of thumb, used by old-time foundrymen in the past, held that no foundry could have overhead mechanization for less than ten molders, and then only at a prohibitive cost. Company claims that lower direct and indirect labor costs, less machining stock required on castings, and greater productive capacity have already resulted.

Prepared to Bid

FOLLOWING a 50 per cent increase in production capacity of its special machinery division, Ferguson Machine & Tool Co., St. Louis, has announced that it is now prepared to bid on the manufacture of specially designed machinery and components.

Known primarily in metalworking industries as designers and manufacturers of roller gear drives for high-speed precision indexing, standardized straight line machines, and standard index tables, the firm also has more than 30 years experience in the design and manufacture of special machinery. Special production machinery includes horizontal boring mills, jog borers, specially designed cam millers, milling machines and precision testing and inspection equipment.

Firm is equipped for the manufacture of high-speed machinery containing a multitude of cams, straight line or dial type transfer machines and equipment requiring intricate electrical or electronic controls. As a subsidiary of Universal Match Corp., Ferguson has facilities for research, design, development and production in mechanical, chemical and electrical fields.



ACCURACY is the key feature of the new Contraves EOTS Phototheodolite, designed for tracking guided missiles and aircraft. The new equipment records time, position, and altitude of the tracking target on 35 mm film at rates of 10 or 30 frames per second. Angle and lead power drive permits simplified rotation of the instrument in azimuth and elevation. Dynamic accuracy of the theodolite is better than 0.1 mil. New unit was developed by Contraves in Switzerland and is available in United States through Oerlikon Tool and Arms Corp.

Slide Program Available

FOUR-COLOR slide-lecture program designed to broaden the understanding of hydraulic component operation has been completed by Denison Engineering Co.

These slide lectures, which will be made available for use in colleges, engineering societies, company training programs, etc., cover the following hydraulic components: axial piston pumps and motors, vane pump motors, directional valves, surge damping valves, flow controls and hydrostatic valves.

The program is designed to keep the engineer and designer up to date on the latest developments in field of fluid power. From 6 to 15 four-color slides are used to describe the operation of the hydraulic units in this series.

Automatic Producer

DEVELOPMENT of automatic manufacturing processes is the "product" of the newly formed Control Products Co. Inc. The firm will design and produce automatic control systems for the steel, nonferrous, electrical, oil, chemical and other process industries. President of the new firm is **Wallace E. Powell,** formerly a control systems engineer for Jones & Laughlin Steel Corp.

New Asst. V. P.

AUTHORITY IN FIELDS of servomechanisms and electronics automation, Nathaniel B. Nichols has been appointed an assistant vice president, Raytheon Mfg. Co.

Mr. Nichols, manager of the re-

Presenting our
4th WORKSHOP in
MATHEMATICAL PROGRAMMING
FEBRUARY 7-25, 1955
HOTEL CLEVELAND

NOW AVAILABLE!
A complete Management Consultant Service to meet YOUR specific needs

- PRODUCTION CONTROL
- INVENTORY MANAGEMENT
- MANAGEMENT CONTROLS
- MATHEMATICAL PROGRAMMING
- OPERATIONS RESEARCH
- SIMULATION PROBLEMS
- HI-SPEED COMPUTERS
- MARKET RESEARCH
- SALARY EVALUATION
- IN-PLANT TRAINING

For further information on our Consultant Service and Training Programs in Inventory Management and Mathematical Programming

CALL • WRITE • WIRE
Executive Services
MANAGEMENT CONSULTANTS
SUperior 1-7110
1040 National City Bank Bldg. • Cleveland 14, Ohio

PROFESSIONAL
SERVICE
CARDS
NOW AVAILABLE IN
AUTOMATION

It has become very evident that Consulting Engineers are playing an increasingly important part in automation.

A survey now being completed indicates that half of the plants employing over 250, or with a financial rating over $1,000,000 plan to "install automatic facilities during 1955."

It also indicates that twenty-one per cent "plan to use services of outside automation specialists." Because of this very high interest we are including standard professional service cards starting with this issue of AUTOMATION. See page 108.

AUTOMATION

search division, joined the firm in 1951. He helped develop several unusual products and led his group through the development stages of mass producing transistors. In addition, he has played a vital role in development of Micronaire, a room air cleaner, and the Ultrasonic Machine Tool which uses a sound wave to drive a cutting tool or drill through hard materials such as glass, stone, tungsten carbide, and precious gems. Also developed under Nichols' guidance, a single-motion duplicator electronic control, guides machine tools to reproduce hundreds of exact replicas from one master part.

Inventory Control

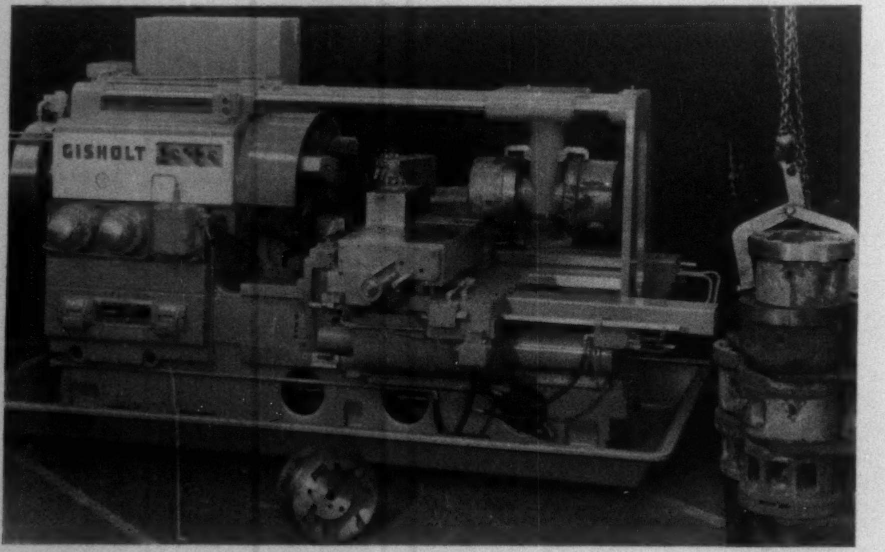
CONTINUOUS SYSTEM for controlling finished stock inventories at Carboloy Dept. of General Electric Co., Detroit, now enables organization to determine its inventory at any time within a matter of minutes.

Providing a daily stock status report, system records all transactions for the previous day's business and lists balances on hand. Organization will save an estimated $20,000 per year.

Formerly all daily transactions affecting the inventory were posted on record cards either manually or with bookkeeping machines. Now with the use of IBM equipment, such transactions are posted automatically from prepunched inventory cards to provide a daily status of approximately 2,500 finished stock items by grade.

Heart of the inventory control system is located in four IBM tub files in the inventory control unit. Each tub holds approximately 50,000 inventory cards. Each inventory card is preprinted and prepunched and represents a standard package quantity, and such quantities vary from one to 100 units per package.

To record inventory deletions, cards representing the items to be removed from the inventory are pulled from tub files and forwarded to the department's machine accounting unit. Inventory additions flow through the machine accounting unit where the respective inventory cards are removed from the master files for the IBM tubs. At the end of day's business a complete record of all transactions is published in form of a stock status report by the machine accounting unit. This shows the status of each item by reflecting the issues, receipts, back orders, on orders, future orders and on-hand balances. A symbol also appears on the report to indicate minimum balances for reordering purposes. Monthly summaries are also published by the machine accounting unit to show year "to date" information which assists the marketing section in making sales forecasts.



INTEGRATION of workpiece loading arbors and special tooling on front and rear slides of an automatic lathe cuts nearly 20 per cent from the original guaranteed time per part—a bonus of eight parts per hour—in the machining of diesel engine cylinder heads.

Carbide tipped tools rough and finish turn the 13⅝-in. OD of these cast iron heads as well as both inner and outer surfaces. Manufactured by Gisholt Machine Co., loading operations on the hydraulic automatic lathe feature addition of a two-station loading device. After a piece is completed, spindle is stopped and unloading arbor is moved hydraulically toward the spindle; air chuck jaws are released, and arbor and lock carry the workpiece clear of the tools.

Loading fixture is hand indexed and power traversed to bring new workpiece up to the spindle. New piece is then clamped in the chuck, and the fixture is again moved away from the tools. After machine is started, operator removes completed piece from the loading arbor and replaces it with a rough casting, ready to be machined.

Nucleus For Expansion

ENTERING THE FAST growing electronics manufacturing field, Elgin National Watch Co. recently purchased Neomatic, Inc.—producers of miniature electronic components. This move will give Elgin a nucleus for expansion into the commercial and military aspects of the electronics industry. Stress will be placed in developing miniaturized electromechanical control devices.

Chairman Announced

ASSISTANT DIRECTOR of engineering, **Robert L. Sink,** Consolidated Engineering Corp. has been named chairman of Institute of Radio Engineer's professional group on instrumentation, Sink will serve as head of the 2200 members national professional society during 1954-55.

The PGI, a special interest organization within the Institute of Radio Engineers, promotes nationwide exchange of information on scientific, technical and industrial advancements in the field of measurement and electronic instrumentation.

MEETINGS AND EVENTS

Jan. 10-14—

Society of Automotive Engineers. Golden anniversary annual meeting and engineering display to be held Sheraton-Cadillac Hotel and Hotel Statler, Detroit. Additional information may be obtained by writing society headquarters 29 West 39th St., New York 18.

Jan. 13-14—

AMA Office Management Seminar. Third of three meetings to be held AMA headquarters, New York, on initiating and developing an office-work simplification program. Additional information may be obtained from association offices, 330 W. 42nd St., New York 36.

Jan. 17-19—

AMA Office Management Seminar. Second of two meetings to be held AMA headquarters, New York, on developing and administering a clerical work-standards program. Additional information may be obtained from association offices, 330 W. 42nd St., New York 36.

Jan. 20-21—

Radio - Electronics - Television Manufacturers Association. Symposium on printed circuits to be held University of Pennsylvania. Additional information may be obtained from Donald W. Cottle, General Electric Co., Syracuse, N. Y.

Jan. 20-21—

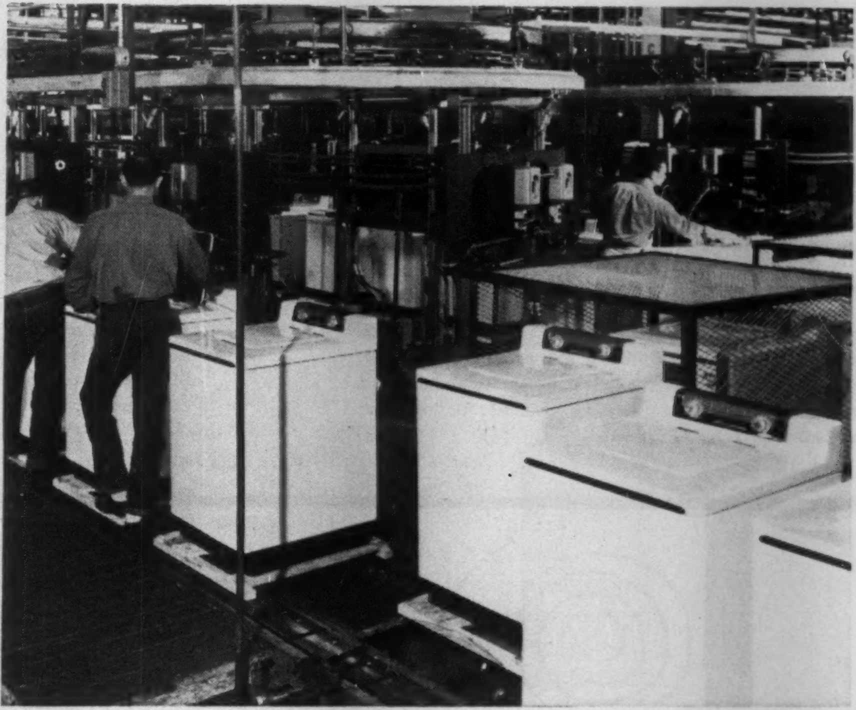
AMA Manufacturing Seminar. First of two meetings to be held AMA headquarters, New York, on practical application of automation. Additional information may be obtained from association offices, 330 W. 42nd St., New York 36.

Jan. 24-27—

Plant Maintenance and Engineering Conference. Annual conference to be held International Amphitheatre, Chicago. Additional information may be obtained from exposition management, Clapp and Poliak, Inc., 341 Madison Ave., New York 17.

Jan. 31-Feb. 4—

American Institute of Electrical Engineers. Winter general meeting to be held Hotel Statler, New York. Additional information may be obtained from society headquarters, 33 West 39th St.. New York 18.



"Each unit does a washing"

without stopping the assembly line

Here's the conveyor system we developed to test automatic washers as they move along the final assembly line.

An overhead conveyor loop, carrying panels with electrical, water and drain connections, parallels the final assembly slat conveyor and travels at the same speed. Washers are hooked to test panels and go through the entire washing, rinsing and spinning sequence without a pause in the line's movement.

Nine out of ten washers get this test, with abbreviated time cycles, on the main line. Every tenth washer is automatically removed to another line, which has its own test loop conveyor. Here washers go through the operating sequence with normal time cycles. As tests end, units are automatically fed into the main conveyor again.

If you are looking for ways to make your operations more efficient and economical, your product more secure competitively, call on our experience in designing and building automatic production.

Call in the MHS engineer.

Mechanical Handling Systems Inc.

AND SUBSIDIARIES

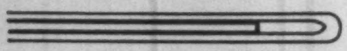
MHS

4632 Nancy Ave., Detroit 12, Michigan

Offices in Principal Cities

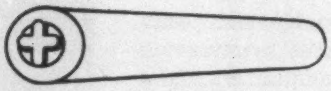
FACTORIES: Detroit, Mich. • Fairfield, Iowa • Albany, N.Y. • Windsor, Ontario

THIS IS AETNA-STANDARD



SEAMLESS TUBE MILLS

Aetna continues to conceive many new ideas for the production of seamless tubing. This continued progress, plus reputation and experience, helps Aetna-Standard to continue as world's leading designer and builder of Seamless Tube Mills.

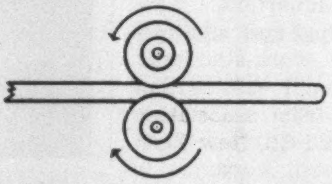


ROLLS

Aetna specializes in manufacture of small and medium-sized iron-base rolls. Aetna is pioneering in the use of Nodular Iron for rolls and castings under trade name of Magaloy.

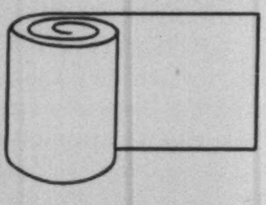
FLAT-ROLLED FINISHING EQUIPMENT

This is one of Aetna's six major product lines. Flat-rolled embraces such equipment as: Shearing and Classifying; Scrubbing and Drying; Recoiling; Slitting and Side Trimming; Roller Levellers (two-high and four-high); Reels of all kinds; and many other products.



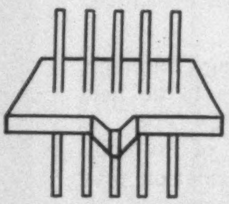
CONTINUOUS BUTT WELD PIPE MILLS

Over the years, new ideas and engineering accomplishments have strengthened Aetna's position as the only builder in America of Continuous Butt Weld Pipe Mills. In recent months, Aetna Pipe Mill equipment has been installed in America, in Canada, in Germany, in England, in Japan and in Argentina.



CONTINUOUS COATING

This year Aetna will have completed the building of 25 continuous galvanizing lines, in addition to several terne and electrolytic tinning lines. Aetna has worked closely with industry in this development and is considered the pioneer in continuous coating equipment.



COLD DRAWING

The world over, Aetna-Standard is recognized as the leading authority and builder of cold draw equipment for tubes and bars. This year marked introduction of several innovations by Aetna, such as the air gripper carriage and hook.

THE AETNA-STANDARD ENGINEERING COMPANY • PITTSBURGH, PA.

Aetna-Standard

PLANTS IN WARREN, OHIO • ELLWOOD CITY, PENNSYLVANIA

GOOD EQUIPMENT BRINGS DOWN PRODUCTION COSTS

SUBSIDIARY and ASSOCIATED COMPANIES

Head Wrightson Machine Company, Ltd., Middlesbrough, England—Great Britain, Finland, Sweden, Norway, Denmark, Union of South Africa, Northern and Southern Rhodesia.

Aetna-Standard Engineering Company, Ltd., Toronto, Ontario, Canada.

M. Castellvi, Inc., New York, N. Y. — Mexico, Central and South America.

Societe de Constructions de Montbard, Paris, France — France, Belgium, Holland, Luxembourg, Switzerland.

Demag Aktiengesellschaft, Duisburg, Germany — Germany, Austria, Yugoslavia, Greece, Turkey, Egypt.

Compagnia Italiana Forme Acciaio, Milano, Italy — Italy.

Aetna-Japan Company, Ltd., Tokyo, Japan — Japan.

Hale & Kullgren, Inc., Akron, Ohio — Representative for the Rubber Industry.

Standard Engineering Company, Ellwood City, Pa.

Trans-World Traders, Pittsburgh, Pa.

Designers and Builders to the Ferrous, Non-Ferrous, Leather, Rubber, and Plastic Industries

AUTOMATION

Indispensable Judgment

In recent years a great deal of conjecture and discussion has indicated that the automation of the future will center around feedback based on vacuum tube circuits with computing machines as the focal point of the automatic factory. In addition, there has been much said concerning automatic machinery of "judgment-replacing" character.

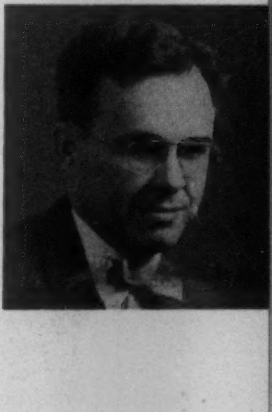
Facing the plain facts of real automation, little will be accomplished by entertaining such viewpoints. While modern industrial electronics offers solutions to some problems never before solved adequately, engineers see it as no panacea. It must be recognized, also, that computing devices and computing elements of all types have been serving industry for many years as component parts of automatic control apparatus. However, computers as judgment-replacing devices appear to offer little hope for the greatest portion of industry from an economic viewpoint.

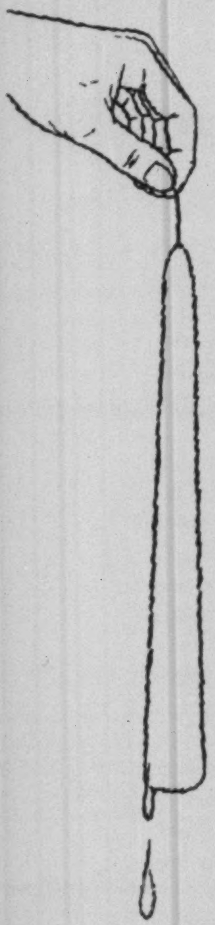
No simple single answer can ever hold the solution to economical automation. Engineers drawing upon all manner of devices known—whether mechanical, electrical, hydraulic, pneumatic, electronic or atomic—will, with ingenuity, invention and know-how, be able to achieve results commensurate with economic demand; and then, only in reasonable time. The myriad of practical problems facing industry today precludes to a large degree the neat and effective solutions attained with single long-term efforts represented by present-day gun-fire controls.

While automatic high-speed computing equipment holds great promise for industry, the basic problems demanding judgment will always be present. Rapidly and continuously changing conditions or demands offer little chance for replacing judgment —the demand is for more and better experienced men. With computing equipment to *aid* men's judgment, the best composite answers to automation problems will be possible; but only with full consideration and use of every means available for achieving the most effective systems.

Bolz

EDITOR





AUTOMATIC MACHINES MAKE HAND-DIPPED CANDLES

Here techniques of automation combine studied consideration of how to make the product with judicious use of hydraulic power equipment and a system of automatic interlocking electrical controls. The result is a simple, rugged, functional system that makes an improved quality product at lower cost

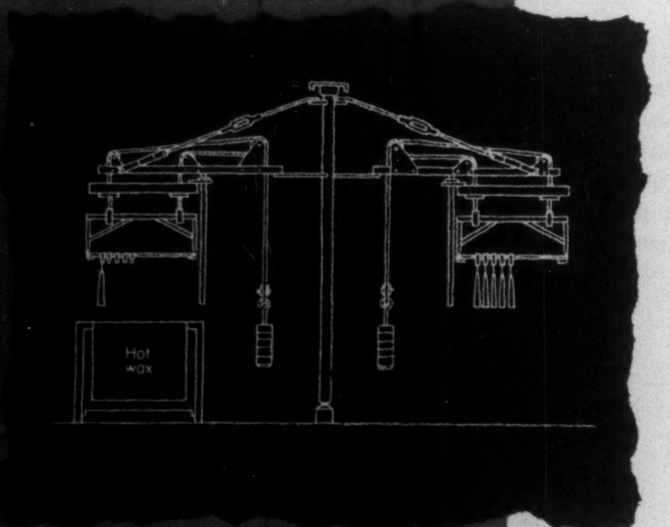
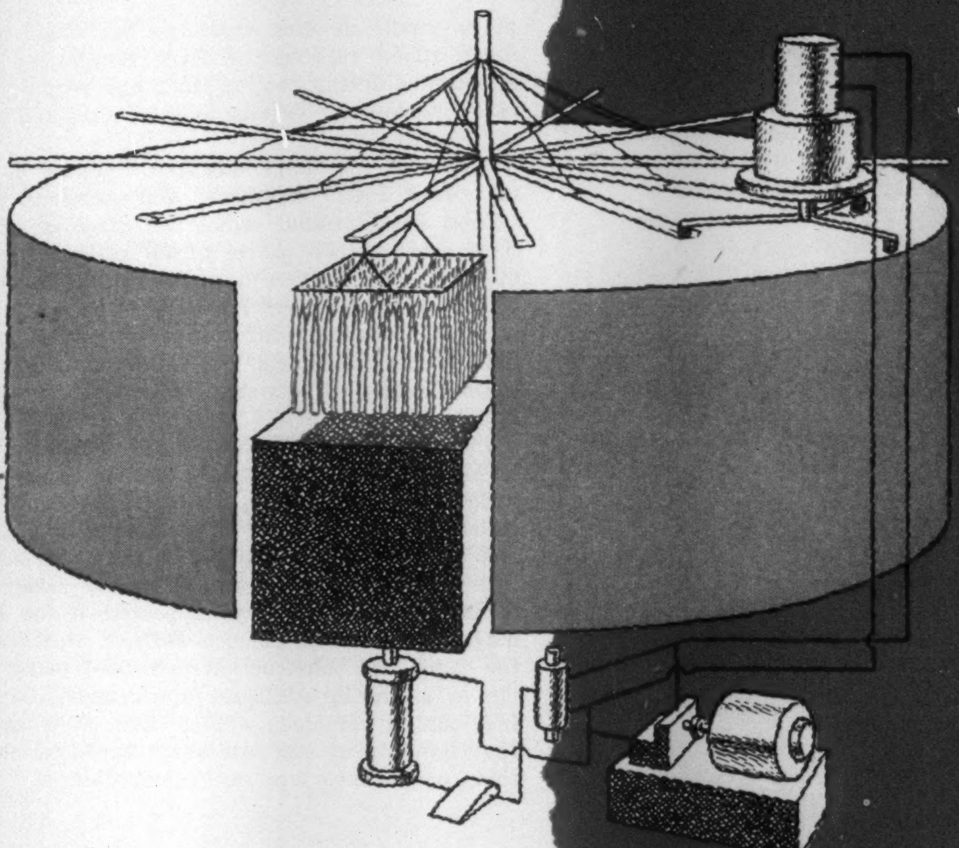


Fig. 1—An early manually operated mechanization of candle dipping. The wheel is turned and the candle carriages are lowered and raised by hand

AUTOMATIC MACHINERY has been used for many years to produce substitutes for handmade products, but in the Standard Oil candle shops at Whiting, Indiana automatic machines are being used to make a better "hand made" product, faster and cheaper. This discussion presents a typical example of how automatic operations can be successfully adopted with practical benefit but without resorting to extremely elaborate or complicated design involving prohibitive cost, even in the case of such a humble and primitive operation as the production of "hand dipped" candles.

Historical Background

A brief review of candle making history presents an interesting background leading up to and justifying the development of means for automatic production of candles formerly made by hand. Beginning with open fires and crude torches,



By CARL J. SCHROEDER
Staff Engineer
Standard Oil Co. (Indiana)

man's endeavor to produce light progressed through various phases of open flame illumination, such as the early whale oil lamps which were smoky and messy, and the odoriferous tallow candles.

The earliest dry candles were produced by soaking a cotton rope or wick in molten tallow or similar substance and allowing it to cool and harden. Later, cotton strings or wicks were given repeated dips in molten tallow which was allowed to cool and harden between dips and this was repeated until a candle of suitable diameter was formed. This process was improved by tying a series of wicks to a stick, dipping these wicks simultaneously into a vat of molten tallow, then placing the stick with its ends on two chair backs and waiting for the candles to cool and harden between dips. To speed up production, a larger number of such sticks or wick holders was employed. This was a very slow, time-consuming operation.

Candles are also produced by pouring tallow into formed molds around a suspended wick. However, the long waiting time for candles to cool and harden, before these molds can again be used to make more candles, leaves a preference for the dipping process. Present-day candle production still em-

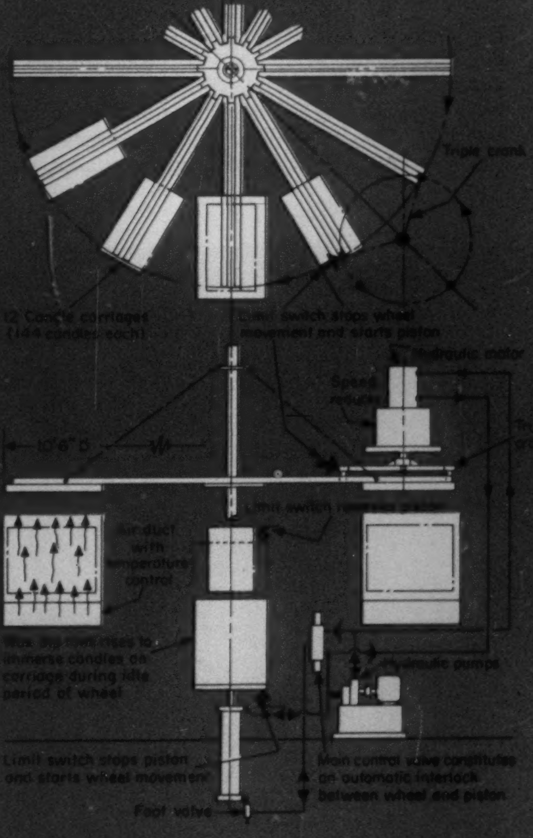

Triple crank
12 Candle carriages (144 candles each)
Limit switch stops wheel movement and starts piston
Hydraulic motor
Speed reducer
10'6" D
Triple crank
Limit switch reverses piston
Air duct with temperature control
Wax dip tank rises to immerse candles on carriage during idle period of wheel
Hydraulic pumps
Limit switch stops piston and starts wheel movement
Main control valve constitutes an automatic interlock between wheel and piston
Foot valve

Fig. 2—Diagram showing general arrangement and functional design of automatic candle dipping machine

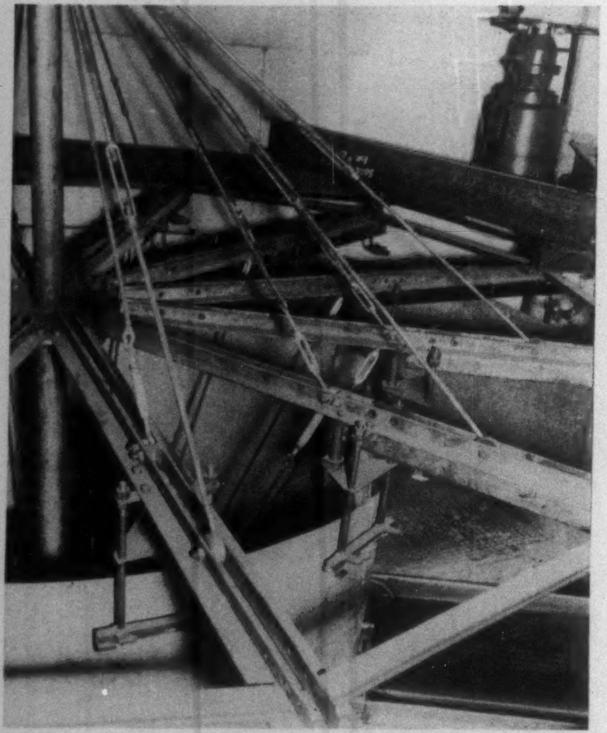


Fig. 3—Partial view of dipping wheel without carriages showing radial arms and receptacles for aligning carriages. Wax tank shown at extreme lower right. Note arrangement of circular side shields for the cooling air. The hydraulic motor on vertical gear reducer at upper right drives a triple crank

ploys candle molding machines but these occupy much space, represent a large investment which stands idle during cooling time, and requires separate machines for various lengths, sizes and shapes of candles.

Whale oil for lamps was soon replaced by "coal oil", now called kerosene, and gasoline was a useless waste product which was often given away if wanted. In the course of oil refining developments, it was further discovered that the extraction of a wax product from mineral crude oil was an ideal substitute for tallow in candle making, did not become rancid like tallow, burned with a clean flame and was dry, clean and pleasant to handle.

Thus, the making of hand-dipped candles became a highly specialized art whose product gained wide acceptance because of the attractive soft luster finish, semitranslucent appearance, and slightly rippled surface as compared to the stern mechanical finish of molded candles whose minor mold marks and color defects appeared to be highly magnified on their smooth surface. Furthermore, the laminated construction presented better quality in strength, stiffness, appearance and burning quality. Molded condles also were given a final hand dip to simulate hand-dipped candles but their appearance was not comparable.

▶ Mechanization

As the demand for hand-dipped candles kept increasing, cost and production problems demanded special attention, for the primitive method of

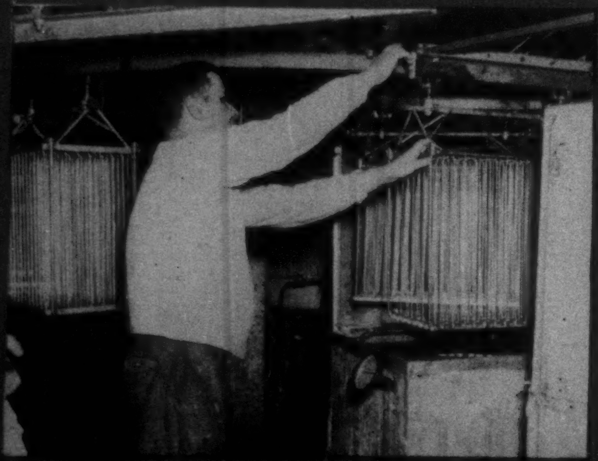


Fig. 4—The operator has just finished pushing a candle carriage filled with fresh wicks into the dipping wheel from the trolley track system and is about to close the latch with his right hand

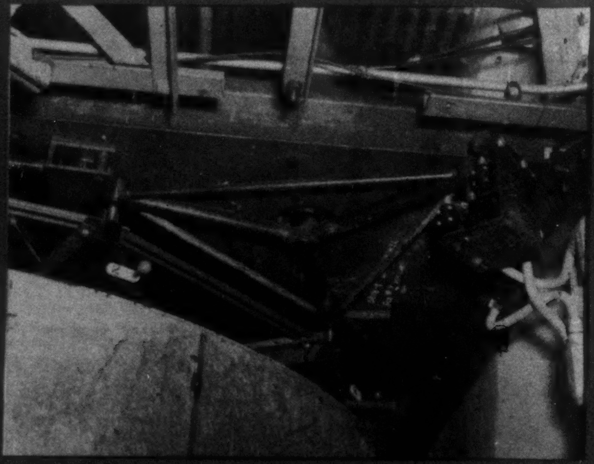


Fig. 5—Triple crank is shown at rest with the wheel in registration. Crank pin at left is about to emerge from its slot while the crank pin in the background is about to enter its slot. At the extreme right are shown three limit swiches which contact the crank

making candles with "wicks tied to sticks resting on chair backs" could not keep pace with modern progress. This resulted in the development of manually operated candle dipping machines consisting of a large wheel, *Fig.* 1, having twelve radial tracks into which candle carriages could be introduced, each carriage holding seven removable bars, each of which held twelve candle wicks. As the wheel was turned by hand, each carriage could be manually lowered to dip the candles into a tank of molten wax, then raised and allowed to cool while suspended on the intermittently revolving wheel while the following carriages of candles were successively dipped. This was continued until the candles attained proper size. The candles were then removed and replaced with specially prepared wicks ready for another dipping cycle. This was a tremendous improvement over the primitive methods previously employed but also resulted in concerned expressions to the effect that this would deprive people of much needed employment. Previously, the candle dipping business was seasonal; twice a year rushes with a layoff of help between these periods. However, following the adoption of mechanized candle dipping additional people were hired and employment continued steadily without layoff, due to greatly increased production.

▶ Automation

Despite these production improvements, it was found that the appearance and quality of candles still varied considerably with each individual operator. A high percentage of rejects and complaints from critical customers was also in evidence. This, in addition to business competition in a field of high labor costs and slender margin of profit, forced consideration of automation or else! The problem was resolved into a need for a product of better quality and appearance, uniformity in shape and size, and lower cost. In addition, certain impending labor legislation threatened to prevent an around-the-clock production schedule which was often necessary to meet sales demands and which meant that production would have to be crowded into one or two shifts of operation. Furthermore, labor had become accustomed to concessions of various kinds, which included technical improvements to lessen labor effort, and this particular

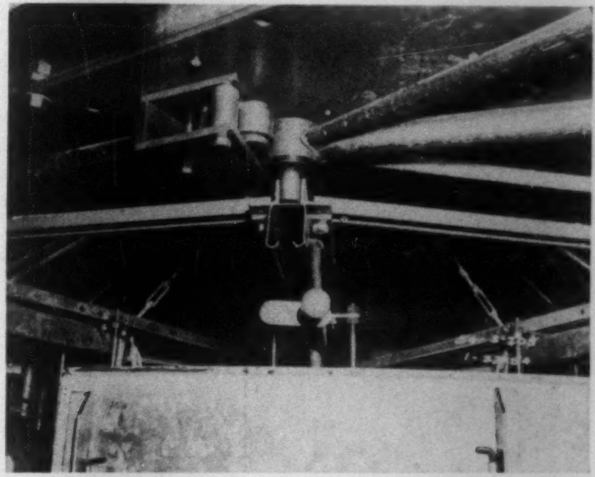


Fig. 7—Triple crank arm in its forward movement has just contacted the roller of the hold-back device and been stopped at the same moment as its hydraulic driving power has been cut off

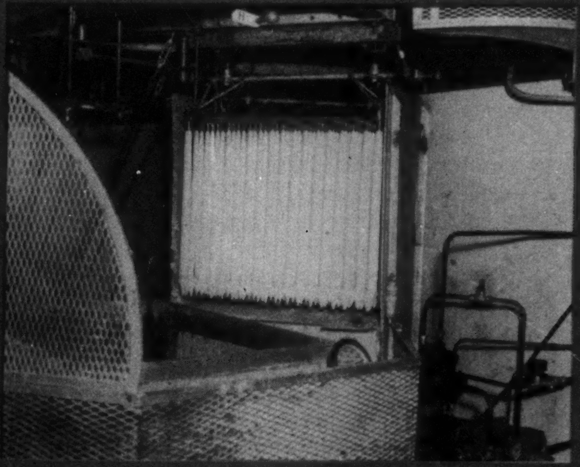
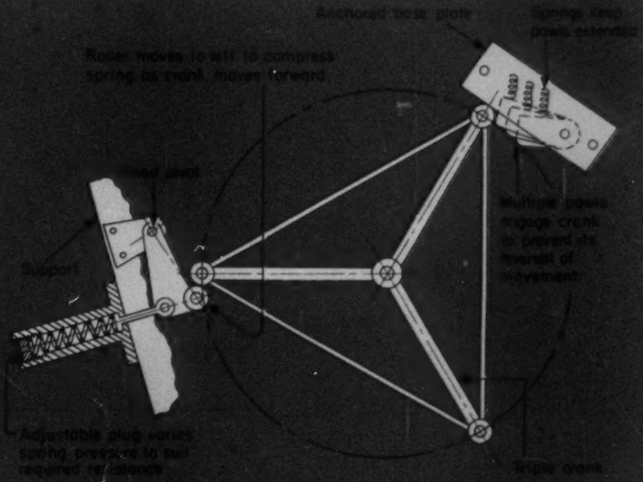


Fig. 6—One carriage directly over the dipping tank has been removed to show the mass of wax on finished candles supported near the periphery of the wheel



Anchored base plate
Springs keep pawls extended
Roller moves to left to compress spring as crank moves forward
Fixed pivot
Support
Multiple pawls engage crank to prevent the reversal of movement
Adjustable plug varies spring pressure to suit required resistance
Triple crank

Fig. 8—Sketch showing general design and operation of registration mechanism

situation was no exception to a desire for "easier" working conditions.

The obvious answer was automation, or simply automatic operation, but an imposing obstacle was the limited expenditure which could be justified for this particular area of business, although there was a tremendous need for modernization and production. It was consequently decided to consider providing only the essential functional requirements for automatic candle dipping operations and controls, devoid of any frills and fancy appearances or refinements, *Fig.* 2. A careful study revealed that a substantial amount of existing equipment could be utilized which, with some modifications, could be worked into the new installation to help keep costs down.

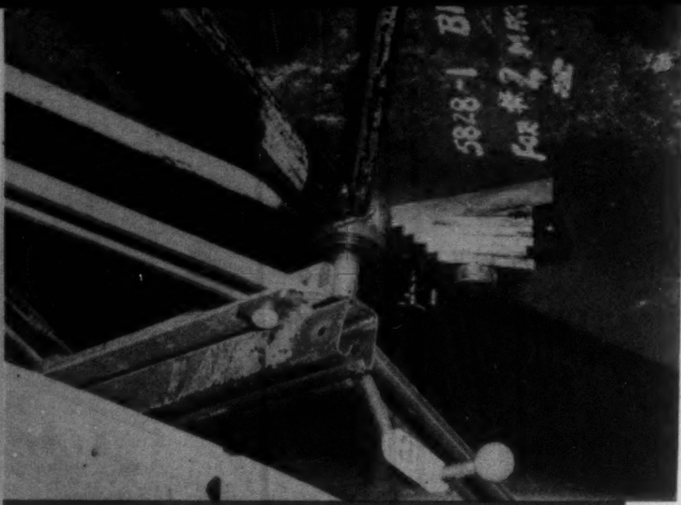


Fig. 9—Multiple-pawl ratchet device is employed to prevent accidental reversal movement of the triple crank at this stage of its movement

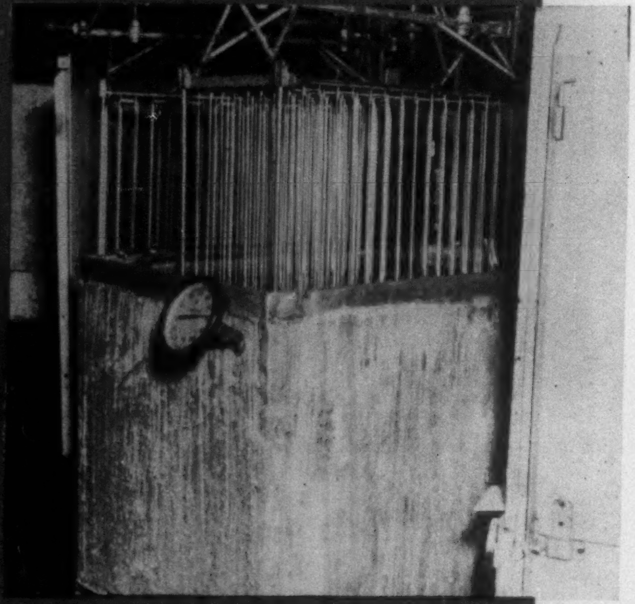


Fig. 10—The wax bath is raised with a smooth, steady hydraulic action to submerge the candle wicks to effect a "dipping" action

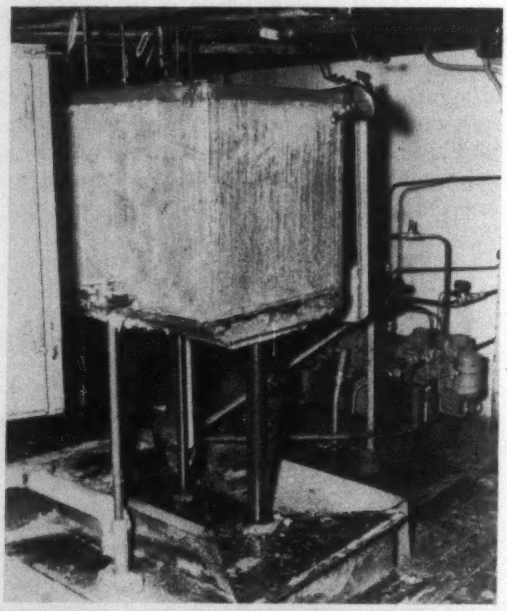


Fig. 11—Dipping tank is shown in fully raised position. Both ends of the hydraulic stroke are cushioned

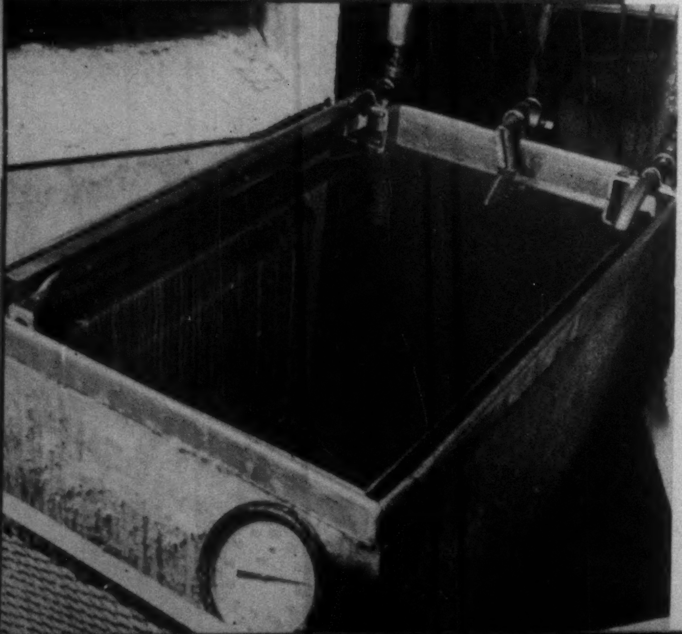


Fig. 12—Wax supply connection to this aluminum dip tank is at the rear center, its discharge submerged. Surplus wax overflows at four weir edges to maintain a constant wax level. Hot water enters a submerged closed coil at right rear, emerging at left rear. A sharp knife-edged blade mounted at the upper left side of the dip tank is kept hot by its contact with a portion of hot water circulating ippe. This blade shears off extending "waxicles" or tails on the longest candles to prevent fouling during their horizontal passage

Preliminary study established ranges and limits of wax temperature and cooling air temperature, timing for dipping and cooling cycles and a general idea of optimum production and operating aspects which would be compatible with specified requirements of a one-year pay-off. Rather than design the equipment to operate under precisely definite conditions, which were difficult to establish accurately because of many critical variables combining in a variety of complications, it was resolved instead to provide in the design an adequate range of operating adjustments in order to permit the most favorable combination of settings for maximum operating efficiency. All adjustments could thus be "inched" towards their most effective point to achieve quality results.

This was especially significant in view of the fact that many and varied effects could result in the finished product by very minute, complex, and sometimes highly elusive conditions in the course of the dipping and cooling operations. Because the wax is being processed through its latent heat range, its characteristics change critically without any corresponding observable change in its apparent temperature. To start from scratch in designing and developing an automatic machine to produce "hand-dipped" quality candles, heretofore considered feasible only by experienced manual skill, to guarantee its successful production operation almost at once, and to do this within the severe limitations of cost and pay-off time requirements, must certainly be conceded as a challenging task of accomplishment.

▶ The Dipping Wheel

It was first established that a suitable starting point was to utilize the existing 10½ foot diameter wheel, *Fig.* 3, operating on a vertical pivoted axis and fitted with twelve equally spaced radial trolley track sections which register with an existing trolley track system for transporting candle carriages between points of operation. This arrangement permits smooth pivotal action, accurate registration, simple design with a minimum of moving parts, and low construction costs. The wheel accommodates twelve candle carriages which are loaded, *Fig.* 4, and unloaded between dipping operations and which are securely latched in proper registration.

The wheel is rotated exactly one-twelfth revolution or thirty degrees between dips by a powered vertical triple crank, *Fig.* 5, whose roller pins enter slots in each of twelve spokes in the wheel, similar to a Geneva action. The crank operates only one-third revolution or 120 degrees intermittently to move the wheel one space. The crank stops in a similar position each time to lock the wheel positively against rotation and in registration by reason of two pins engaging two slots in the wheel simultaneously; one pin is just entering one slot as the other pin is just ready to leave the other slot if motion were continued. This simple triple crank drive design is employed to effect a gradual acceleration and deceleration of the wheel which, when loaded with twelve gross of finished candles, presents considerable inertia load on the mechanism if the speed is changed too abruptly. Maximum wheel speed in the middle of its movement is desirable to keep production time loss due to transport movement at a minimum.

Gradual accumulation of wax on twelve gross candles located near the periphery of a large diameter wheel, *Fig.* 6, causes a considerable variation in inertia forces. The effect, combined with other inertia forces, tends to cause a fully loaded wheel to slightly over-run its registration point after the driving power has ceased. Although any one of numerous means can be utilized to accomplish close registration of the wheel at its stopping point, an inexpensive but unique adjustable spring-loaded stop mechanism, *Fig.* 7, is employed to give just enough resistance to overcome the inertia forces of the loaded wheel and crank mechanism after driving power has ceased. Any slight overtravel is promptly and automatically restored by this device which acts on one arm of the triple driving crank and whose spring cushion also reduces shock and impact loading on the affected mechanisms, *Fig.* 8.

The force required to stop the wheel is much less if applied to the crank rather than directly to the wheel. When the triple crank again resumes motion under power, the stop device presents only a nominal resistance at the first instant of movement but this resistance quickly diminishes as the crank proceeds to move past the stop mechanism which then automatically returns to its initial position. Considering the simplicity of this design the stop mechanism and its range of adjustment have proved quite satisfactory.

As a further means of assuring proper registration of the wheel and to prevent accidental reversal at this point from any of the possible causes, a multiple-pawl ratchet has been provided to contact one arm of the triple crank as it passes to the left, *Fig.* 9. The crank is thus securely held in close registration between the ratchet device and the hold-back mechanism.

▶ Dipping Tank

In conventional candle dipping operations, the candles are usually lowered into a tank of molten wax. In this operation the wax tank is raised to submerge the candles by smooth, steady hydraulic action, *Fig.* 10, with means for accurately adjusting the rate of dipping speed and the transition of speed at both ends of the stroke, yet permitting a full stroke with soft cushioning in both directions, *Fig.* 11. Accurate repetition of the stopping point at the upper end of stoke is essential to properly shaped candle tips.

The rise and recession of the dipping tank are timed to occur only while the dipping wheel is at rest. The entire mechanism is so interlocked that the tank cannot rise if the wheel is not at rest in its proper registration. Neither can the wheel revolve unless the tank is down at the bottom of its stroke.

The reason for raising the wax tank instead of dipping the candles downward into the wax is that inertia forces due to the up and down dipping movement of candles during production speeds causes the soft body of wax on the candles to sag and slump downward. Soft candles during dipping operations are incidental to minimum cooling time which favors production. Since the cooling rate of wax has practical limitations, the obvious remedy to speed up production is to raise and lower the wax tank. Furthermore, this procedure is less costly and mechanically much simpler than providing a smooth and closely controlled vertical movement to each carriage. Mechanical vertical movement of candle carriages introduces additional dynamic and vibration factors which tend to produce objectionable surface defeats and deformation of the thermoplastic candles while suspended on their wicks, thus seriously affecting their final appearance and quality.

A constant wax level in the dipping tank is controlled by an overflow weir which completely surrounds the dip tank on four sides, *Fig.* 12, and empties into a telescoping tube which projects into a vertical drain line, shown in *Fig.* 11. The supply of fresh wax enters the dip tank through a submerged outlet to avoid surface disturbances and bubbles. A riser loop in the wax supply line prevents accidental automatic draining of the dipping tank when the pump stops, and a special vent prevents syphoning action under similar conditions, but provision is made for draining the dipping tank when so required.

Specially designed closed heat-transfer coils in the wax tank function to maintain substantially uniform wax temperature by means of hot water circulation at a fixed temperature. Special flexible hoses constitute suitable moving connections at the rear of the dipping tank for the hot water supply and for the wax supply.

As candle dipping progresses, long wax tails or "waxicles" form at the lower end of the candles, *Fig.* 16. These tails, if allowed to accumulate and harden on long candles, would interfere with the horizontal passage of the candle carriages over the dip tank while moving in a circular path with the wheel. To remove these "waxicles" automatically and continuously, a sharp-edged blade, *Fig.* 12, is mounted in a horizontal position just above the left side of the dip tank, attached to a portion of a hot water circulating pipe to keep the blade hot. As a carriage of long candles moves with the revolving wheel immediately after each dip, the soft "waxicles" are cut off and drop back into the wax bath as they contact the hot sharp knife edge. Similar wax tails in the course of earlier dipping methods were removed from time to time by a crude and slow hand method; each individual tail being clipped off with hand scissors.

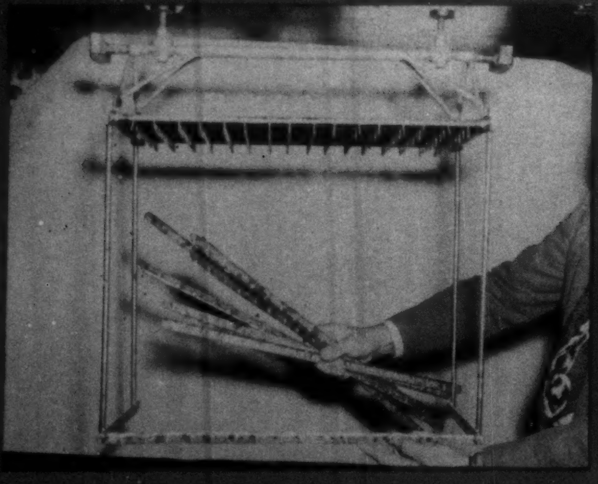


Fig. 13—Typical candle carriage showing removable hanger frames at ends and lower wick holder bars which are assembled without tools or separate fasteners. Cushioned bumpers at both ends have curved shape to facilitate negotiating curves in the trolley track. Rubber cushion washers at lower end of the trolley hangers absorb vibration

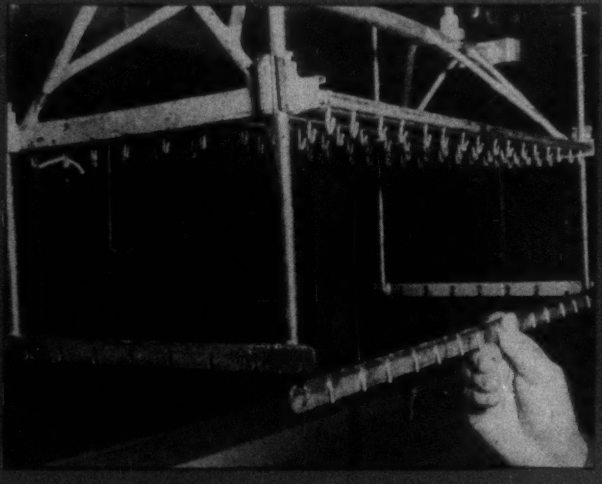


Fig. 14—Partial assembly view of carriage and parts showing simplicity of providing quick adjustment for shorter candles. Design of interlocking joint slots facilitates assembly and removal

Wax Circulating System

Circulation of wax in the dipping tank at a carefully controlled temperature and constant rate is only one of many critical factors which affects quality, production and appearance of dipped candles. A semiclosed, corrosion resisting system is employed to avoid contamination of product. A wax circulating pump and supply tank are located low enough to receive overflow drainage from the dip tank weirs. Rate of circulation is just enough to maintain a fixed constant level of wax in the dipping tank during greatest demand, with minimum disturbance in the wax bath. The wax supply lines are all designed to automatically drain back to their source when the pump stops, to obviate frozen wax lines. Substantially constant operating temperature of the wax at all points in the system is automatically and effectively maintained by circulating hot water through closed coils in the wax supply tank, through tracer lines for all wax lines and the wax circulating pump, and through closed coils in the wax dipping tank. The water temperature is automatically controlled by an adjustable regulator.

Candle Carriages

Previously, carriages used for candle dipping consisted basically of a frame riding on two trolley hangers and supporting a series of removable rods which by means of spring clips held suspended a number of precut and prewaxed individual candle wicks which had free swing and required certain clearance to minimize contact with each other during dipping and handling operations, *Fig.* 1. Spoilage of candles, due to inter-contact while still soft and due to accidentally dislodged candle holder bars and insecurely held wicks, was excessively high. Handling of wicks involving special preparation and insertion in the wick holders was a tedious and time-consuming operation representing a considerable percentage of total candle cost.

The new candle carriage, *Fig.* 13, consists of upper wick holder bars mounted integrally on a rack supported from trolley hangers riding in an overhead trolley track system. Rubber cushioned bumpers mounted at both ends of the carriages absorb vibration and shock, and facilitate pushing rows of carriages along the trolley track system. Rubber suspension cushions are also employed in the trolley hangers to isolate vibration from the trolley track to the candle carriages. Means are provided to effect a uniform vertical adjustment on all carriages with reference to the trolley track.

An arrangement of removable hanger frame members and lower wick holder bars, adjustable to suit various lengths of candles, *Fig.* 14, permits a continuous length of candle wicking to be easily and quickly strung in place without need of previous treatment or cutting, *Fig.* 15. The lower wick holder bars slip readily in place into interlocking and locating slots one at a time, and are held in place by the nominal tension of the wicks under the wedge hooks attached to these bars as the wicking operation progresses.

Hooks at top and bottom have a specially de-

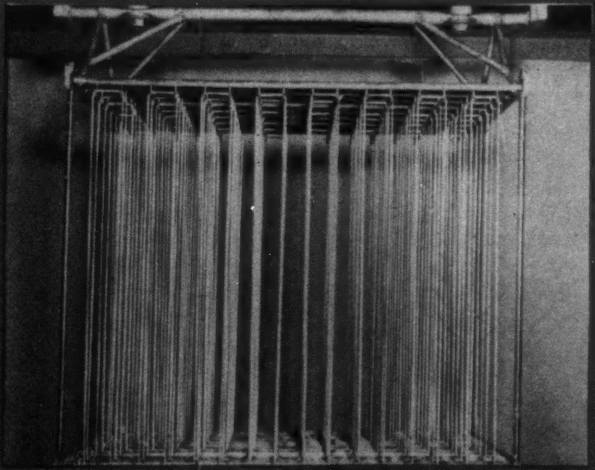


Fig. 15—Assembled candle carriage, completely wicked and ready for dipping operations. The entire wick is in one continuous length, to save handling time

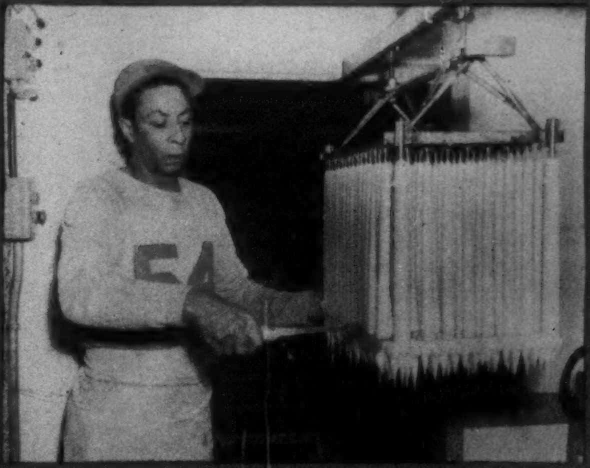


Fig. 16—Candles are removed from the dipping machine when attained proper diameter. While still soft and plastic, they are cut at their base with a large sharp knife as shown. Note the "waxicles" which form at the bottom ends of candles during dipping

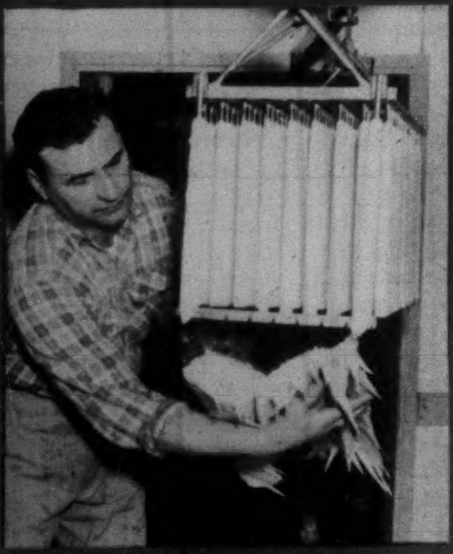


Fig. 17—Immediately after the cutting operation the operator removes the lower carriage parts with their accumulation of wax. This wax is readily reclaimed for further use

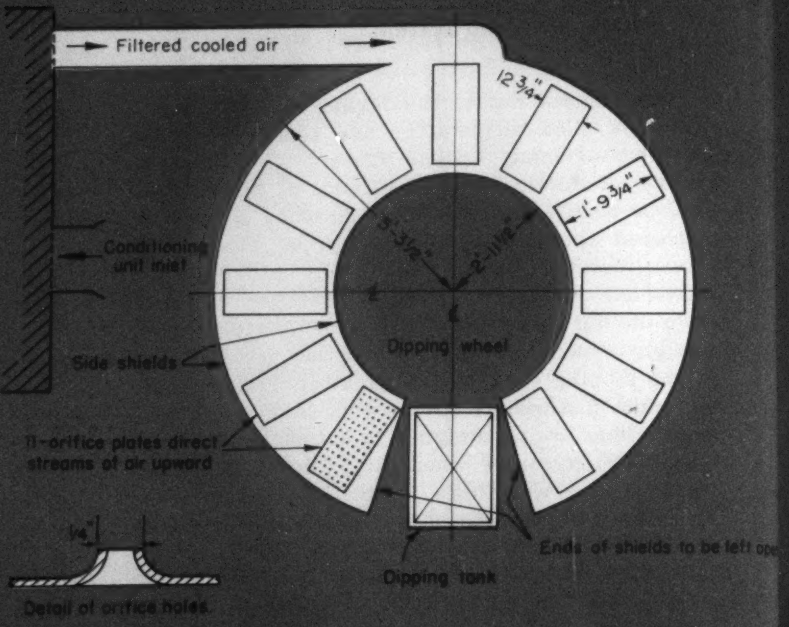


Fig. 18—Plan of Cooling Air System

signed crotch to readily receive the wick and hold it with a firm grip, yet easily release the wick with only a slight pull when lifted out of the crotch. This positive arrangement for holding and spacing candle wicks prevents candles swinging into contact with each other and permits a much closer spacing resulting in greatly increased capacity of candles per carriage and per dip. By this new method it is feasible to dip a whole gross of candles at one time. The highly effective grip of the special wedge hooks on the candle wicks also serves to prevent the candles from slipping out of registration in the course of subsequent operations which involve butt trimming and a special final dip, either white or in color. The wicking operation is performed at a location away from the dipping machine and previous to loading the carriages into the dipping machine.

In the dipping operations, the carriage members which extend into the wax bath become coated with an accumulation of wax similar to that on the wicks. After a predetermined number of dips, candle diameter is checked by a quick caliper measurement; the carriages are removed from the machine and candles manually cut off to correct length with a large sharp knife, *Fig.* 16, using the top edge of the lower wick holder bars as a cutting gauge or guide. To prevent wax building up on this guide edge during dipping operations, it was found effective to design this edge as a sharp knife edge facing upward.

The hanger frame members and lower wick holder bars of the carriage are designed to be readily separable and removable without the use of tools. With their accumulation of soft wax still adhering, *Fig.* 17, these parts are collected and passed through a simple dewaxing operation from which they emerge clean and ready for another carriage assembly and wicking operation.

▶ Cooling Air System

Proper handling of a product such as thermoplastic wax—which is neither fluid nor solid during its transition while cooling and possesses a very low rate of heat conductivity—requires special and critical design considerations to solve the peculiar problems involved. Seasonal operating conditions, imposing a considerable variation of ambient temperature, and production requirements involving quality control for size, appearance and uniformity, must be taken into account.

A system utilizing forced recirculation of filtered and artificially cooled air in a room enclosure, with means for automatic temperature control, was chosen to effect controlled cooling of candles between dips. Filtered air is used because small specks of dirt deposit readily and show up prominently on fresh white candles. Forced air is used because cooling of candles by natural convection is too slow, not uniform and very undependable, especially during hot summer weather. A system is needed which affords critically uniform results the year around, regardless of weather conditions or differences in individual characteristics of operators.

It has been established that even a moderate horizontal movement of cooling air against the sides of hanging candles caused them to warp and bow very preceptibly but that an upward blast of cooling air is very effective, especially when shielded on the sides to reduce lateral dispersion of cooling air, *Fig*. 2. A circular header, *Fig* 18, was provided with perforated plates having nozzle shaped orifices to efficiently direct an upward flow of cooling air, parallel with the hanging candles. These orifice plates are located directly below positions where the candle carriages come to rest and cover areas slightly larger than that occupied by the candles in each carriage.

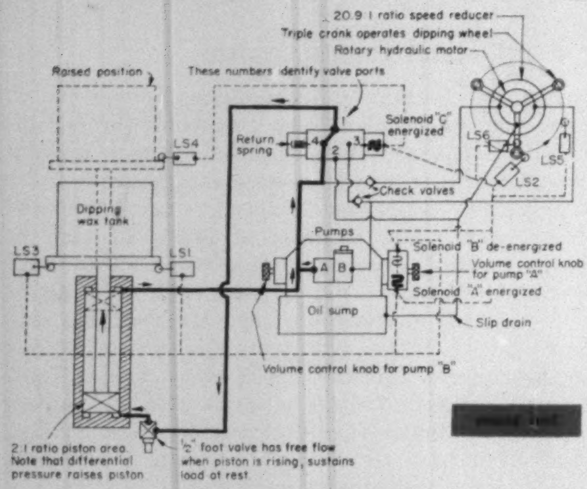
Thus the cooling air is introduced directly where needed, thence returning and recirculating continuously through the air filtering and cooling system. It may be interesting to note that with insufficient cooling candles become too soft, tend to sag and require more dips to attain proper diameter, whereas too much cooling results in surface defects, poor appearance, lack of uniformity in shape and size, and difficult cutting operations immediately following the final dip. The volume of air is kept constantly high for good distribution but its temperature against the candles is carefully adjusted and maintained for optimum results in combination with other operating adjustments whose combination has a critical effect on the final results. A correct combination of operating adjustments within a seemingly narrow range is essential to a high quality product with pleasing appearance, *Fig*. 19.

▶ Drive and Control System

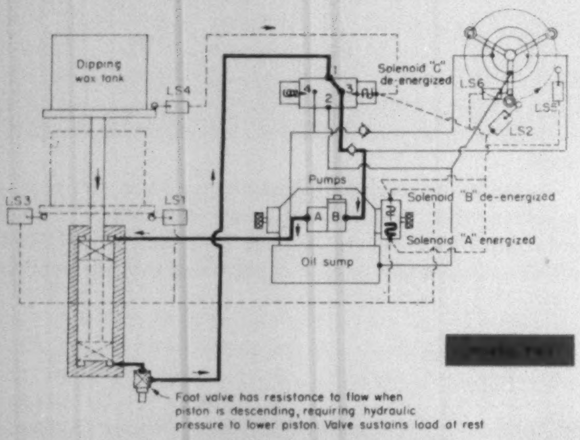
The intermittent and repetitive movements of this machine involve long travel in various directions, quite widely separated. Means for adjustment are required for accurate timing and for complicated variations in speed, acceleration and deceleration. The sequence of functions must be positive and continuously automatic. An arrangement of dependable interlocking controls is necessary to avoid malfunction under all conditions, and provision is necessary for manual control of any single phase of the whole cycle of mechanical functions. Furthermore, the machine as a whole must operate dependably under production schedules, free from need for frequent operating attention, adjustments and repairs.

The design of such a machine whose operation depends entirely on solid metallic machine elements such as gears, levers, cams, linkages, etc, would require a multitude of intricate parts and bulky frame whose complicated design, construction and operating maintenance would be a costly proposition. The aspects of frequent adjustments and troublesome maintenance which would be necessary to maintain proper operation of machinery involving a large number of wearing parts is a serious consideration based on practical experience.

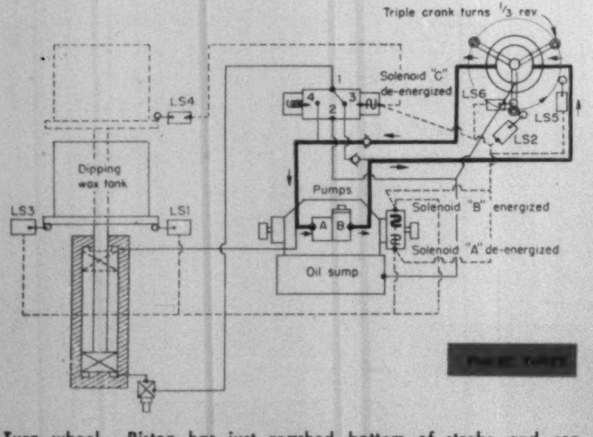
A judicious choice of hydraulic power equipment resolves this problem into an extremely simple solution which meets almost in a single package, all the requirements of a combination of reciprocat-


20.9:1 ratio speed reducer
Triple crank operates dipping wheel
Rotary hydraulic motor
Raised position
These numbers identify valve ports
LS4
Return spring
4
1
2
3
Solenoid "C" energized
LS6
LS5
LS2
Check valves
Dipping wax tank
Pumps
LS3
LS1
A
B
Solenoid "B" de-energized
Volume control knob for pump "A"
Solenoid "A" energized
Oil sump
Slip drain
Volume control knob for pump "B"
2:1 ratio piston area. Note that differential pressure raises piston
½" foot valve has free flow when piston is rising, sustains load at rest

Raise Piston. Triple crank has just contacted limit switch 2 which has de-energized solenoid *B* to stop crank and energized solenoids *A* and C to start raising piston. Crank is hydraulically locked in position. Energized solenoid *A* results in hydraulic pressure at port *A* which causes piston to raise. Piston will not raise unless *LS6* is in contact with crankpin


Dipping wax tank
LS4
1
4
2
3
Solenoid "C" de-energized
LS6
LS5
LS2
LS3
LS1
Pumps
A
B
Solenoid "B" de-energized
Solenoid "A" energized
Oil sump
Foot valve has resistance to flow when piston is descending, requiring hydraulic pressure to lower piston. Valve sustains load at rest

Lower piston. Piston has just reached top of stroke and contacted limit switch 4 which has de-energized solenoid C to shift valve to lower the piston by hydraulic pressure. Crank remains hydraulically locked in position. Solenoids *A* and *B* remain unchanged, same as for Phase 1


Triple crank turns ⅓ rev
1
4
3
2
Solenoid "C" de-energized
LS4
LS6
LS5
LS2
Dipping wax tank
Pumps
LS3
LS1
A
B
Solenoid "B" energized
Solenoid "A" de-energized
Oil sump

Turn wheel. Piston has just reached bottom of stroke and contacted limit switches 1 and 3 which has de-energized solenoid *A* and energized solenoid *B* to start triple crank to turn. When triple crank completes one-third revolution the next crank arm will contact limit switch 2 and the cycle will continue to repeat itself through the three phases until the machine is stopped. Triple crank will not turn unless piston is completely down and in contact with *LS3*

ing and revolving motion with long travel and complicated variations of movement and control combinations, *Fig.* 20. Application of power with choice of movement and controls is flexible, action is positive and wear aspects are favorable because of enclosed lubrication and sealing against entry of dirt. The few mechanical devices employed in this connection can be of simple and rugged design and the whole can be readily adapted to existing or preselected equipment or structures. The hydraulic power can be easily piped to any point in any direction, as needed.

An otherwise complicated system of automatic and interlocking controls is kept reasonably simple by the use of electrical limit switches and relays to actuate the solenoid operated hydraulic control valves through a complete cycle of machine operation, *Fig.* 21. This consists basically of (1) raising the piston, (2) lowering the piston, and (3) turning the wheel. Extra electrical pushbuttons, *Fig.* 22, operating on a separate circuit, are provided for manual control of these same functions, independently, for purposes of testing, inspection, maintenance or experimenting. These manual controls also serve to rotate the wheel during the manual loading and unloading operations on the wheel, and to raise and lower the wax tank during the initial dipping of candle wicks when it is desired to hold them submerged in the wax bath for a short interval.

For manual control, with the selector switch set on *Hand* position, a momentary contact of the *Turn* button causes the wheel to turn one space and automatically stop in its next position of proper registration. Continued pressure on the *Turn* button causes the wheel to move continuously until after the *Turn* button is released but always completing its movement to stop at its next point of registration. The raising and lowering of the wax tank may be manually controlled by pressing either the *Raise* or *Lower* buttons, for which continuous contact is necessary to complete the stroke. The piston may be held under pressure at its extreme end of travel without harm. Release of either button during any point of piston movement stops motion at that point.

Fig. 21—Schematic hydraulic flow diagram. Pump A serves piston. Pump *B* serves rotary motor. Ports A and *B* produce pressure only when solenoids A or *B* respectively are energized. Speeds are adjustable independently by means of volume control knobs. Oil can flow into ports A or *B* when solenoids A or *B* respectively are de-energized. Controls are electrically interlocked to prevent piston rising except when crank is at rest in proper position of registration, and to prevent crank turning except when piston is at rest at bottom of stroke. Limit switches *LS3* and *LS6* are safety interlock switches. Piston and triple crank cannot be operated simultaneously

Hydraulic power equipment and controls are commercially available in a wide selection to suit almost any conceivable application. Versatility and ease of adaptation to many special conditions and requirements favors consideration of hydraulics for application in many machine mechanisms. Hydraulic equipment is in a field of development whose potential benefits are now coming into greater prominence.

General Operation

Twelve carriages which have been previously filled with candle wicks are loaded onto the wheel of the candle dipping machine as the wheel is rotated semiautomatically one space at a time. Each carriage of wicks is then given an initial dip of slightly longer duration than by automatic operation, manually controlled by a pushbutton. This phase could be automatic but this is not essential. The machine is now ready for automatic operation which begins when the operator turns the control switch from *Hand* to *Automatic* position. Automatic dipping continues with alternate turns of the wheel and raising and lowering of the dip tank until 24 dips have been made. The operator can readily anticipate when the candles are nearly to size and checks their diameter with a simple caliper gauge.

When the candles attain proper diameter, which takes approximately 45 minutes, the automatic controls are turned off. A manual control pushbutton then signals the wheel to turn one position at a time during which a carriage full of candles is removed and later replaced in a similar manner with another carriage already strung with new wicks. The candles are then cut at their lower end which permits the entire lower framework below the upper supporting members to be removed with their wax deposits and wick stubs. These latter operations are manual but are performed easily and quickly.

This arrangement of candle dipping incorporates some new and unique features in a novel manner and combination of application. Predominantly functional design embodies a complicated series of operations and adjustments into a comparatively simple and rugged machine at a nominal cost, yet highly effective in production and quality control. A ten per cent or greater average production loss due to "culls" has been eliminated by automatic operation and production can now be maintained right through the hot spells of summer weather which heretofore seriously impeded production.

Early candle dipping performed by experienced operators employing special techniques in dipping wicks attached to wooden sticks by the old primitive hand methods produced a few dozen candles per hour. Subsequent development of mechanized but manually operated "hand dipping", *Fig.* 1, was a great improvement over primitive methods but production bogged down during the hot summer weather. Now comes automatic production of "hand-dipped" quality candles with sensational improvements including high production rates which can be maintained under adverse weather conditions, consistent quality control and a reduction of physical labor burden at no penalty of reduced employment. A significant aspect of automatic operation is its dependably relentless pace, unaffected by rest periods, breaks or let-up due to human indisposition involving manual effort and mental alertness. TABLE 1 clearly shows that automation pays.

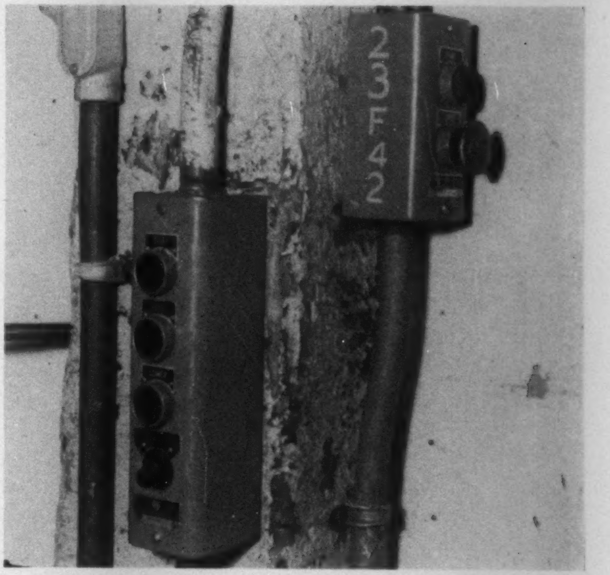


Fig. 22—Simple arrangement of clearly marked pushbuttons combined with a completely interlocked control system provide foolproof operation which does not require skill or adeptness

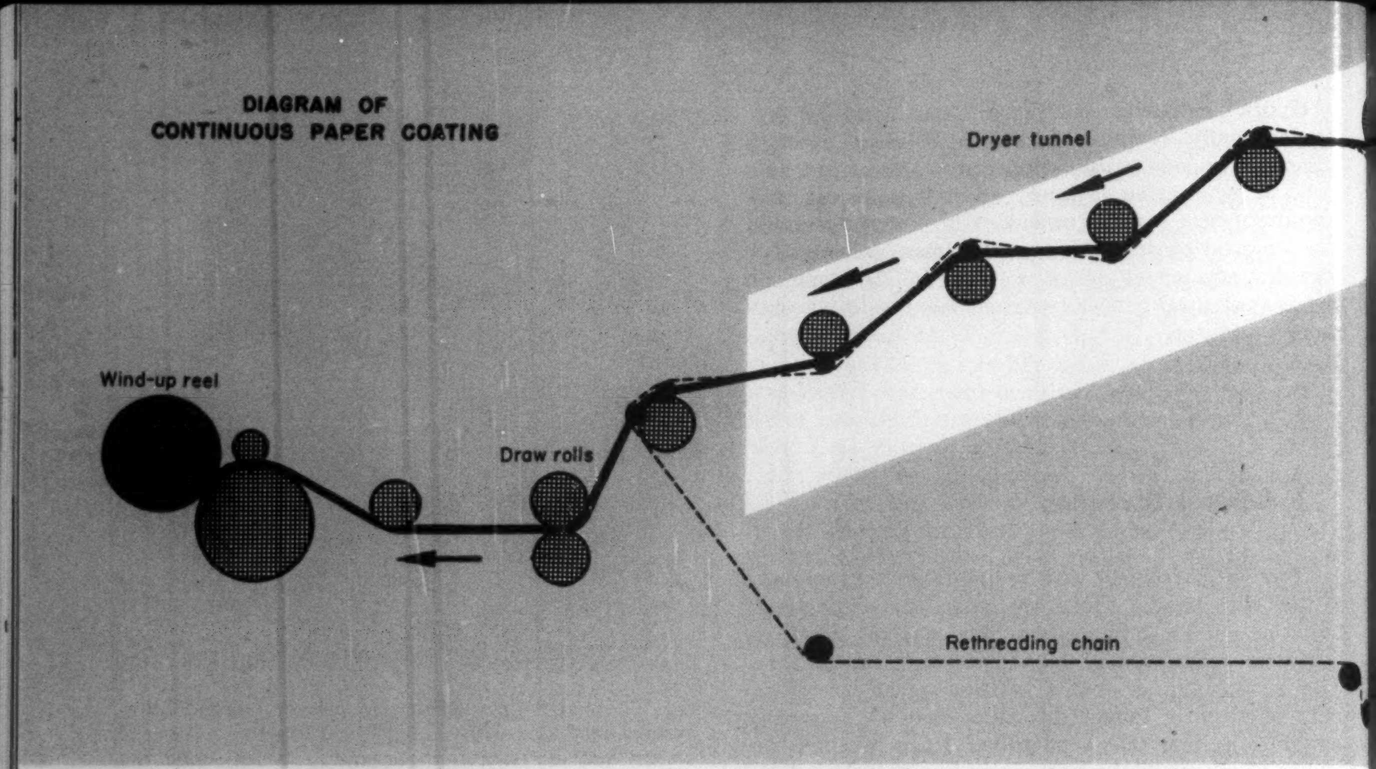
This new automatic candle dipping machine was designed to exhibit neither glamour nor elegance, but it seems to present endless fascination to those who watch "hand dipped" candles with their characteristic shape and finish taking on form automatically with "no hands".

The automatic candle dipping equipment described in this article has been successfully producing candles in commercial quantities for several years and is protected by U. S. letters patent 2,647,279; 2,647,282 and pending applications.

TABLE I

Comparison of Candle Dipping Production

Machine	Production/Man Hour		Production/Machine Hour	
	(Summer)	(Winter)	(Summer)	(Winter)
Manual	259	548	259	648
Automatic	3456	3456	1728	1728
Added Output (% of original)	1234	433	567	167



AUTOMATION TODAY

HIGH SPEED PAPER COATING

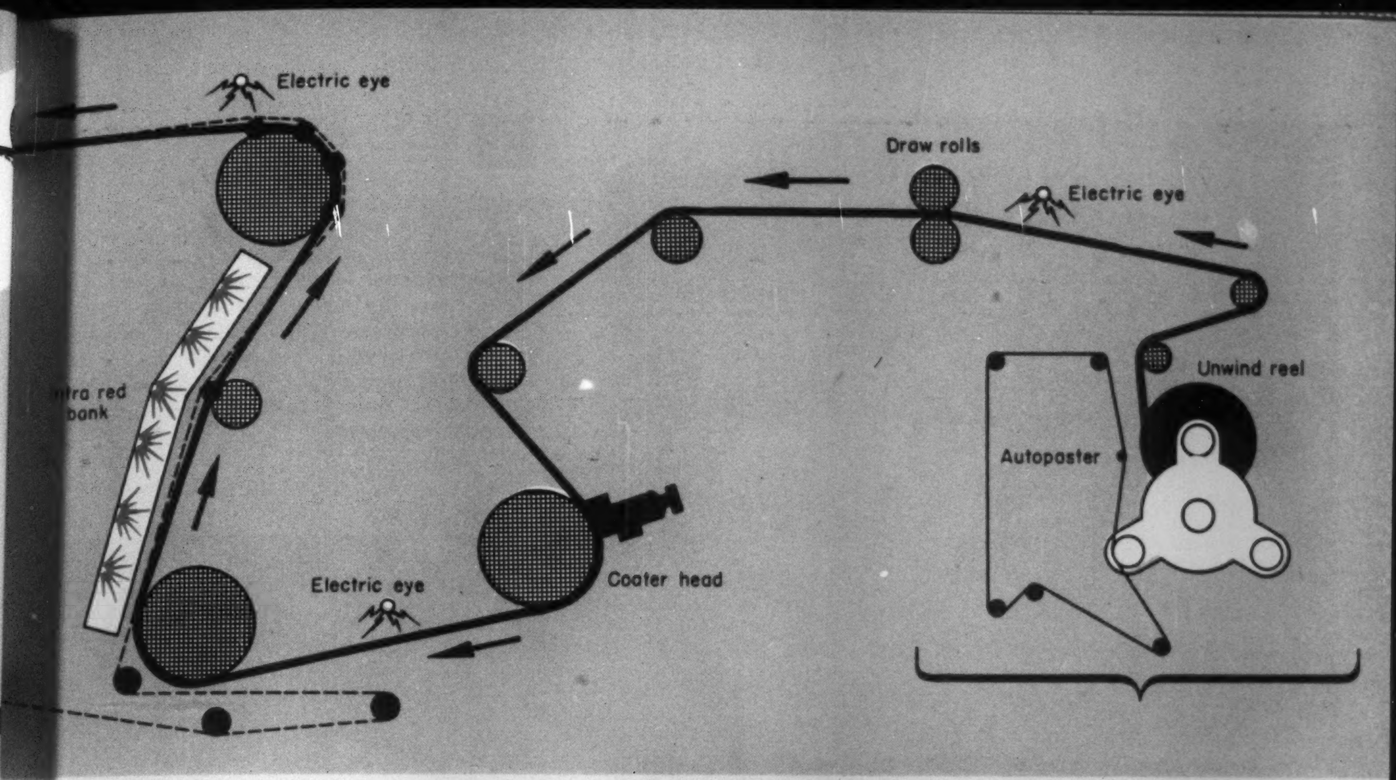
APPLICATION OF COATING or color to rolls of paper 190 inches wide by 42 inches in diameter is accomplished at 2000 feet per minute in an installation of patented design built by the Rice Barton Corp.

Stock is unwound from a spool at the first station, fed through draw rolls, passed through the coating head after which the coating is set by infrared lamps and dried in a hot air tunnel. The paper moves through draw rolls again and is wound on a spool at the last position.

Features to incorporate automatic operation into the units are included. A paster reel station accelerates to machine speed a new roll of stock and splices it to the material going through, then automatically severs the web on the practically unwound spool of paper. There is also an arrangement on the wind-up end which accelerates an empty spool, lowers it into contact with the paper, transfers to the winding position, and thus automatically starts a new spool into the operation without any reduction of machine speed. These handling devices at each end of the process provide for one continuous unbroken web of material to be going through the machine at all times.

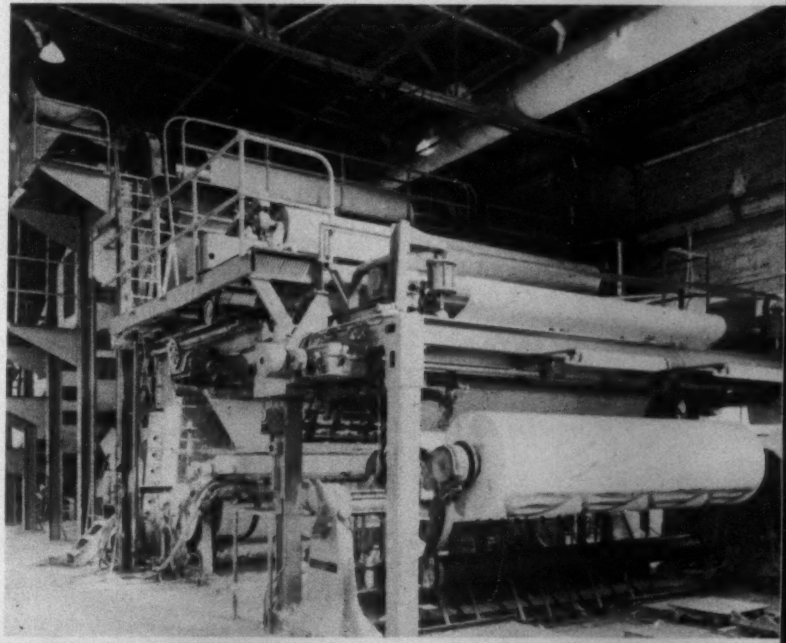
Should the web of paper break down, a break detector sets into motion a series of operations. The fountain of coating is moved away from the coating roll to stop the flow, the coating roll is washed down, a brake is applied to the roll of paper supplying the machine. The rest of the machine continues in operation until the remaining web has been removed from the machine and wound up on the spool. To assist in putting the machine back on the line, a carrier bar mounted between chain drives picks up the web after the coater head and threads over all rolls and drums through the infrared and air tunnel sections; locations which are otherwise relatively inaccessible. The break detector automatically sets in motion devices that move the bank of infrared lamps away from the sheet path so that the threading device may pass without interference.

As can be seen in the accompanying photographs, such a machine with its automatic devices for operation, control, and safety represents a sizeable design and installation engineering project in a well-advanced stage of automation.


Electric eye
Draw rolls
Electric eye
Unwind reel
ntra red
bank
Autopaster
Electric eye
Coater head

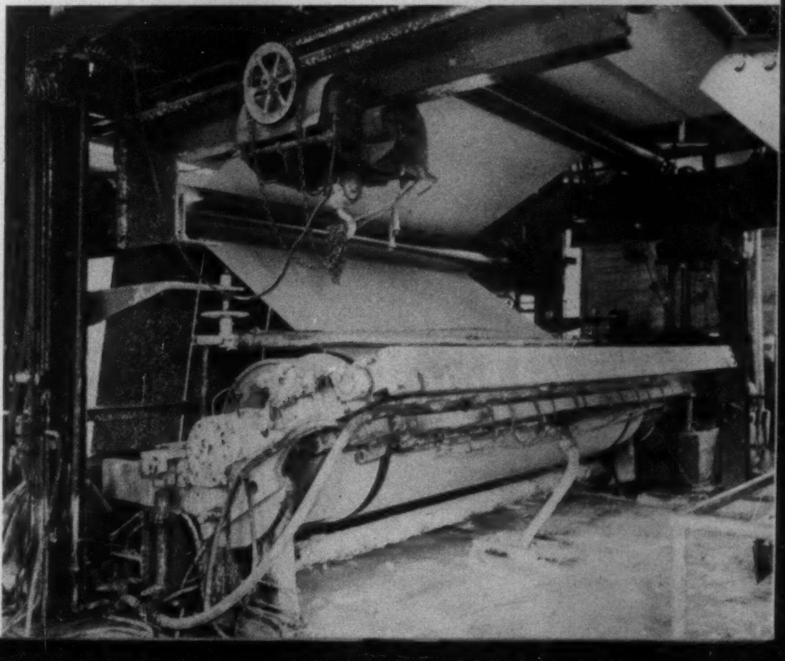
1

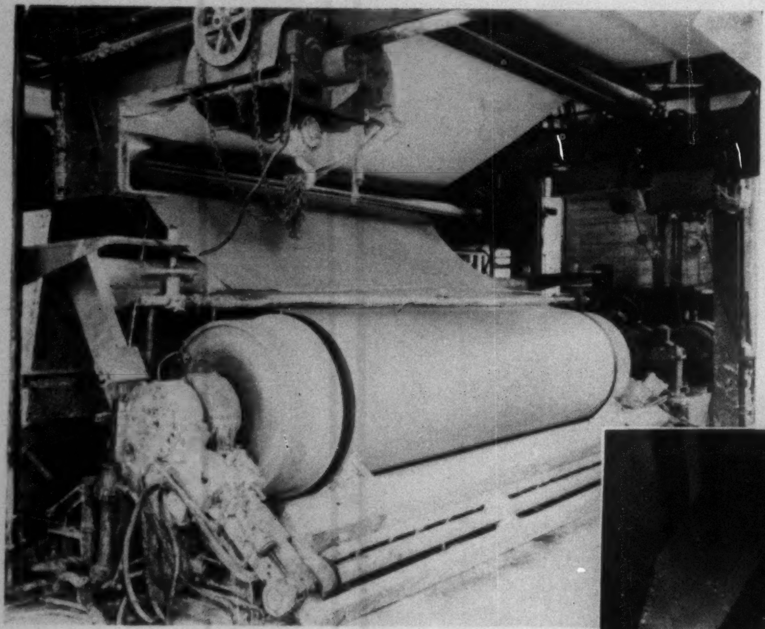
Wood Autopaster automatic reel is the first station of the paper coater. Three-position reel shown here with one spool at left being unwound, one spool empty at bottom and a roll ready to be moved into the automatic transfer position. The new roll is accelerated to machine speed, the splice is made, and the material on the unwound spool is automatically severed. This transfer and the maintenance of proper running tension are fully automatic; the operator need only index the roll of paper when he sees it is about to run out.



2

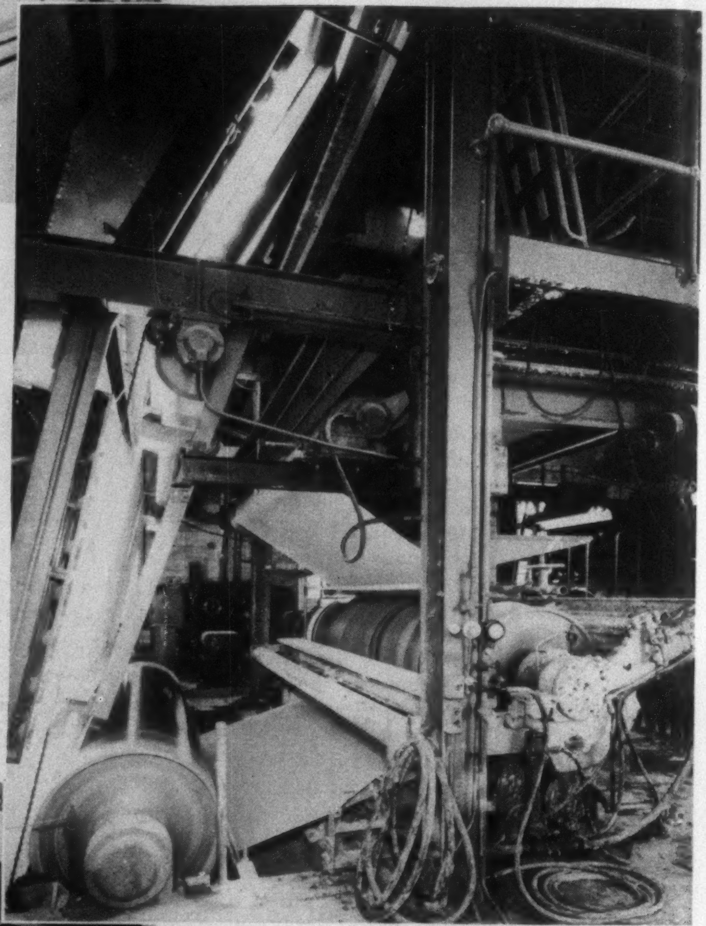
Coating head is a rubber covered drum. Paper passes between this drum and a "doctor" blade that forms a trough or fountain in which color or coating is maintained by continuous feed. The surface of the drum presents a resilient backing for the blade enabling it to doctor off the excess color as the sheet passes.





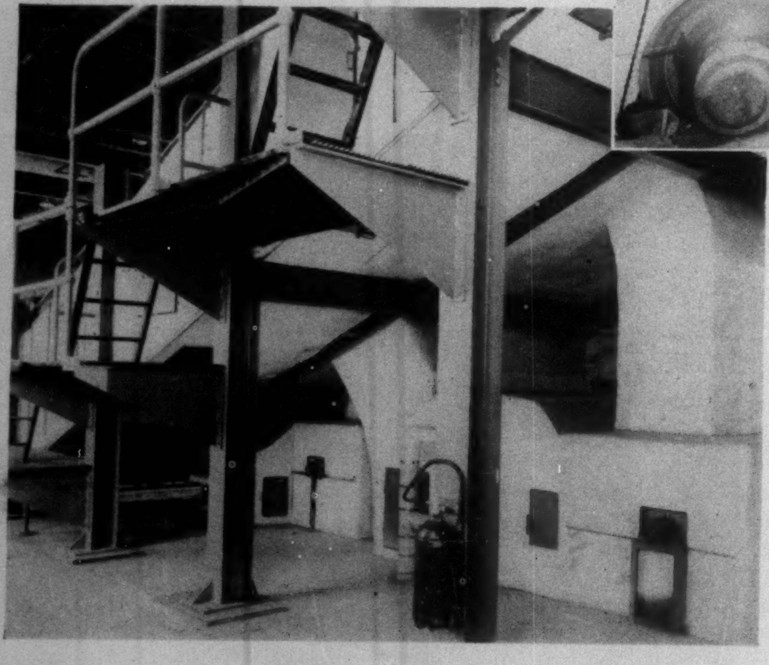
3

In the event of a break in the paper, the break detection system initiates action. Hydraulic cylinders rotate the fountain assembly into the down position shown and the liquid flows away from the drum. Another set of cylinders retracts the doctoring mechanism so as not to mar the drum. Picture shows head lowered during sheet threading operation.



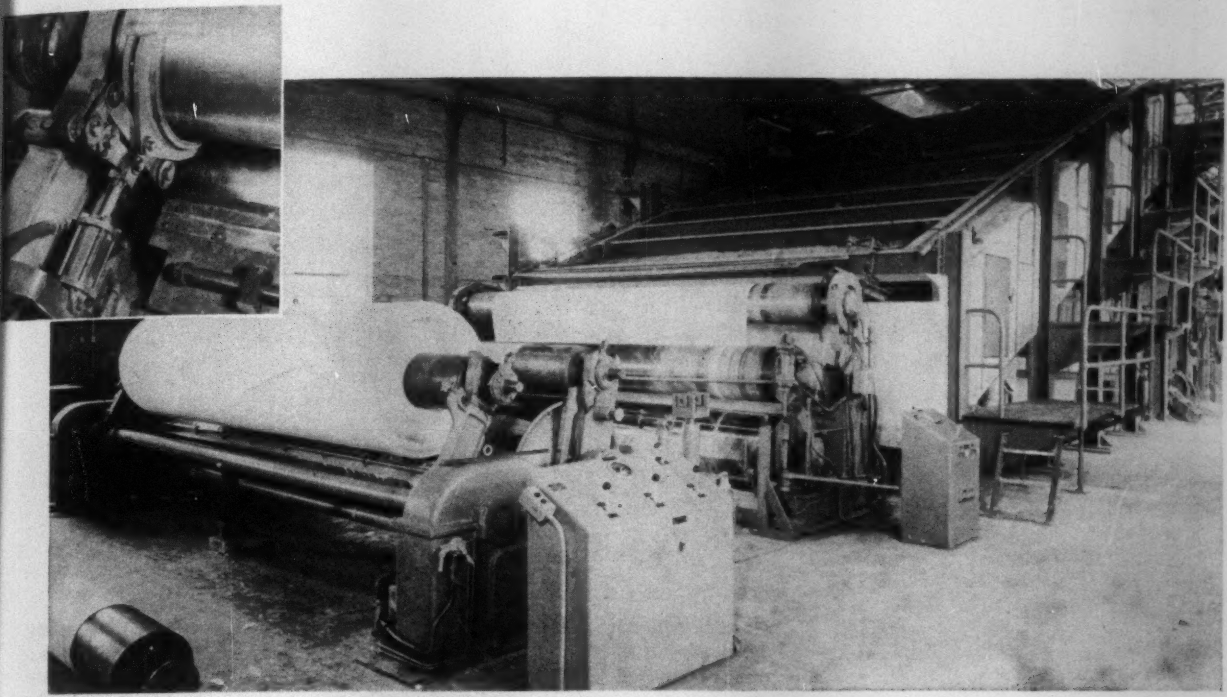
4

From the coating head the sheet rises vertically past a bank of infrared lamps. Here the coating is set in a fraction of a second. Visible at the left is the rethreading chain. A carrier bar is supported by such a chain on each side of the machine and takes the full width of the sheet through the infrared and dryer sections at threading speed if a break in the web has occurred.

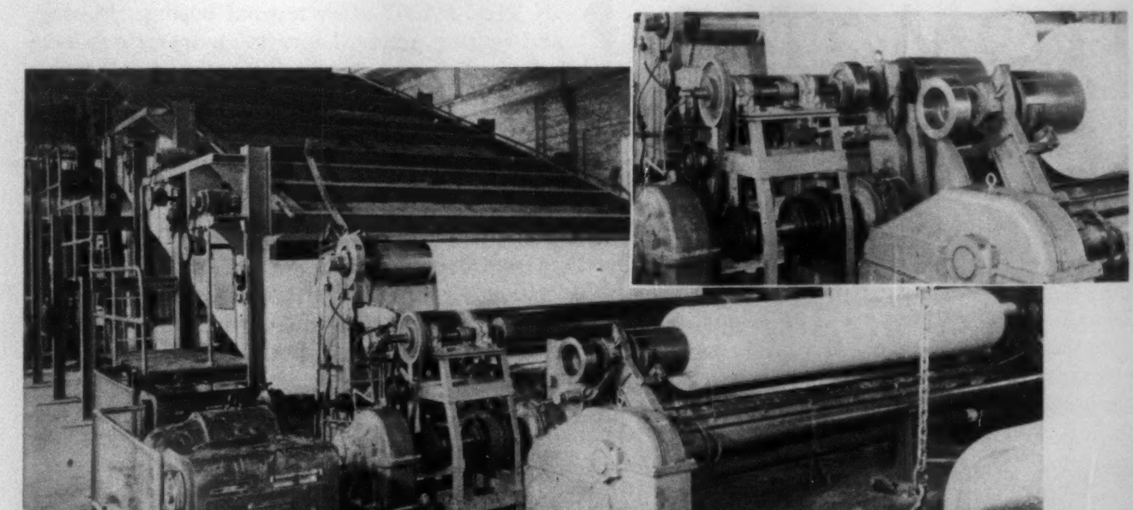


5

Over 35 feet long, this hot-air tunnel is a dryer for the coated paper. Close-up view shows structural work, platforms to access doors, insulated plenum chambers and duct work to sloping tunnel.



6 Draw rolls and reel are on windup end of machine. New spool shown directly on top of 48 inch diameter drum is accelerated by a patented device to the surface speed of the drum and lowered into contact with the paper. The web of material is automatically started on this spool. As the operator at the hydraulic control cabinet causes the full spool to be raised from the driving drum, the brake is automatically applied to prevent the outer layers from whirling loose from the roll.



7 Completed roll is lowered to the floor and the new spool is transferred to the windup position. Insert shows drive mechanisms for drum and accelerating clutch drive at top engaged in clutch hub of empty spool—air cylinder under pillow block retracts clutch assembly before spool is lowered onto paper.

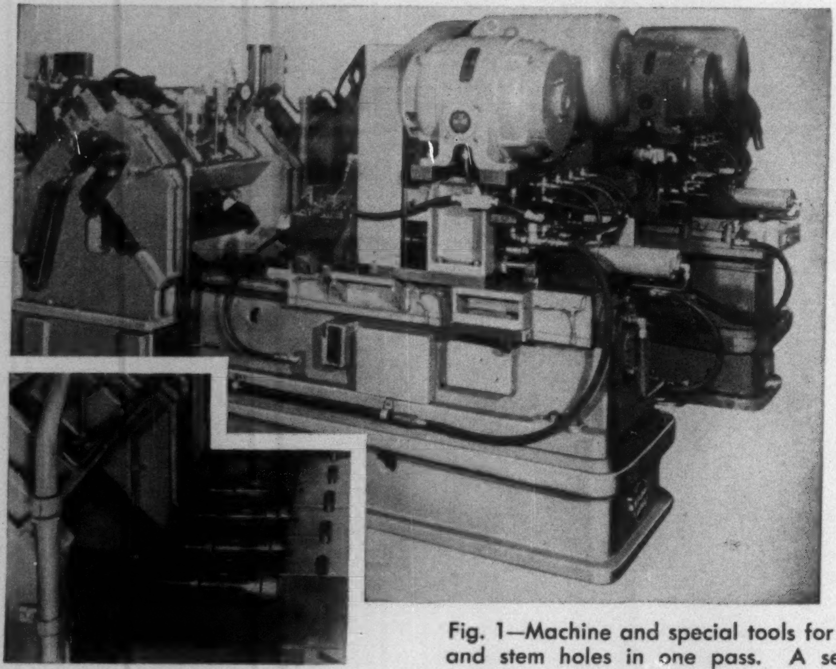


Fig. 1—Machine and special tools for finish-machining four valve seats and stem holes in one pass. A second 4-spindle head completes remaining valve seat and stem hole operations in the V-8 cylinder heads. Coolant is applied to the valve stem boring tools. Any finish from 20 to 100 microinch can be produced, and holes held straight, round, and to size

PRECISION TOLERANCES HELD IN AUTOMATIC BORING

IN THE PAST, after normal boring, reaming, and seating, manual corrective operations have been necessary to obtain concentricity between engine valve seats and stem holes and to obtain the necessary finish and roundness required. A new tooling method developed by W. F. & John Barnes Co. is completing this operation automatically in machining cylinder heads for overhead valve engines.

Utilizing a multiblade tool for forming the valve seat and a modified gun drilling tool for boring valve guide holes, results show that this automatic progress-through transfer type machine has consistently held concentricity of 0.0005-inch (total indicator reading) between valve stem hole and valve seat, and that the quality of these two machined surfaces is high.

Precision maintained by the machine and tools solves a production problem. The 100 per cent inspection system previously employed can be substantially modified and in general, reduced work handling, physical effort and production costs are realized.

Performance tests show that special carbide tools employed will produce 15,000 or more precision valve seats and 2000 stem holes before tool change or regrinding is necessary. Gross production of the machine now in operation in an automotive plant is 120 V-8 type cylinder heads per hour.

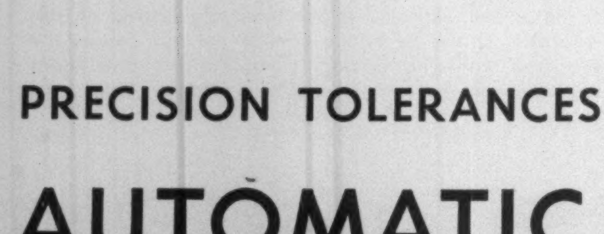
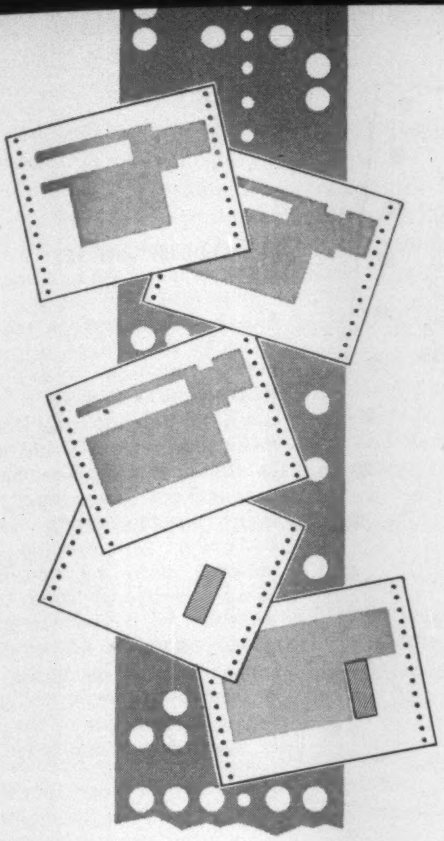


Fig. 2—V-8 cylinder head showing valve seat and guide holes of the type now finish-machined to precision tolerances automatically



PART TWO

After establishing the groundwork in the first article of this series, we get down to brass tacks, or as the illustrative forms indicate, down to drill pressure rods. From low limit inventory to arrival of purchased stock, application of the integrated data processing concept makes the paperwork process almost completely automatic—with reduction of errors, costs and delays

By **P. B. GARROTT**
Director of Market Development
Standard Register Co., Dayton, Ohio

INTEGRATED DATA PROCESSING BRINGS AUTOMATION TO PAPERWORK

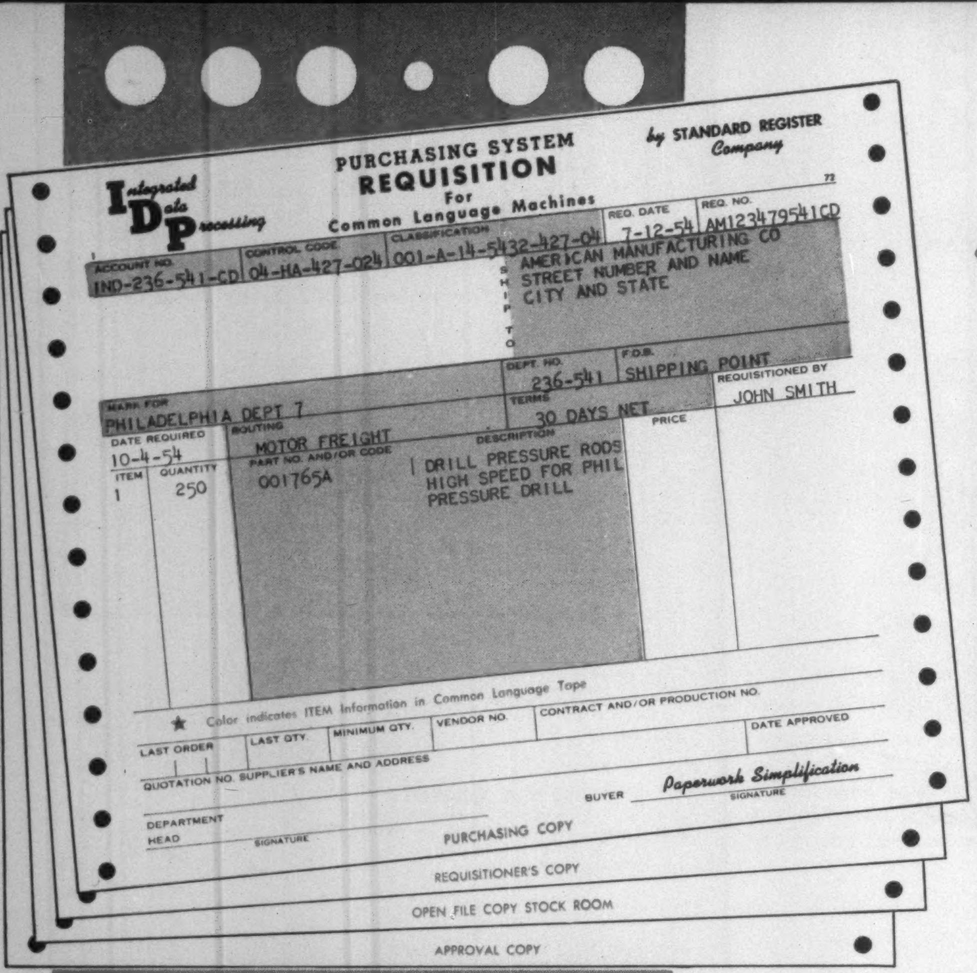
BROAD PRINCIPLES and theories involved in integrated data processing were presented in the first article of this series. Common language was defined and described as it relates to punched tape as well as to certain office machines within this concept. From this basic study were developed two rules for achieving integrated data processing:

1. Record data at the point of origin on office machines which create punched tapes or cards as the automatic by-product of the recording operation.
2. Process original and subsequent data on office machines which read and punch tapes or cards, so that all data are self-perpetuating.

Up to this point, integrated data processing has been described and discussed in a rather academic fashion. A certain amount of theory-spouting and rule-quoting is necessary to provide basic, uniform understanding of what is to follow. Too much of it, however, is likely to be more confusing than too little. Accordingly, let's leave the academic atmosphere in favor of one closer to practical reality. Any questions or misunderstandings regarding earlier remarks are likely to disappear as the following examples of applied integrated data processing are presented.

In the preceding article, reference was made to necessary repetition of information under today's business operating conditions. The example cited was that of a common purchasing-receiving operation. Let's analyze such a routine in more detail at this point, to see where and how integrated data processing might be applied profitably.

In setting the background for this example, let's assume that we are an industrial organization. Going into the final assembly of our finished product is a part or subassembly which is to be purchased from an outside source. Consequently, we maintain a stock of that item, in accordance with our requirements—and our inventory control people are



Integrated Data Processing

PURCHASING SYSTEM
REQUISITION
For
Common Language Machines

by STANDARD REGISTER Company

72

REQ. DATE 7-12-54
REQ. NO. AM12347954ICD
ACCOUNT NO. IND-236-541-CD
CONTROL CODE 04-HA-427-024
CLASSIFICATION 001-A-14-5432-427-04
SHIP TO AMERICAN MANUFACTURING CO
STREET NUMBER AND NAME
CITY AND STATE
DEPT. NO. 236-541
F.O.B. SHIPPING POINT
REQUISITIONED BY JOHN SMITH
MARK FOR PHILADELPHIA DEPT 7
TERMS 30 DAYS NET
DATE REQUIRED 10-4-54
ROUTING MOTOR FREIGHT

ITEM	QUANTITY	PART NO. AND/OR CODE	DESCRIPTION	PRICE
1	250	001765A	DRILL PRESSURE RODS HIGH SPEED FOR PHIL PRESSURE DRILL	

★ Color indicates ITEM Information in Common Language Tape

LAST ORDER | LAST QTY. | MINIMUM QTY. | VENDOR NO. | CONTRACT AND/OR PRODUCTION NO. | DATE APPROVED

QUOTATION NO. SUPPLIER'S NAME AND ADDRESS

BUYER *Paperwork Simplification*
SIGNATURE

DEPARTMENT HEAD
SIGNATURE

PURCHASING COPY

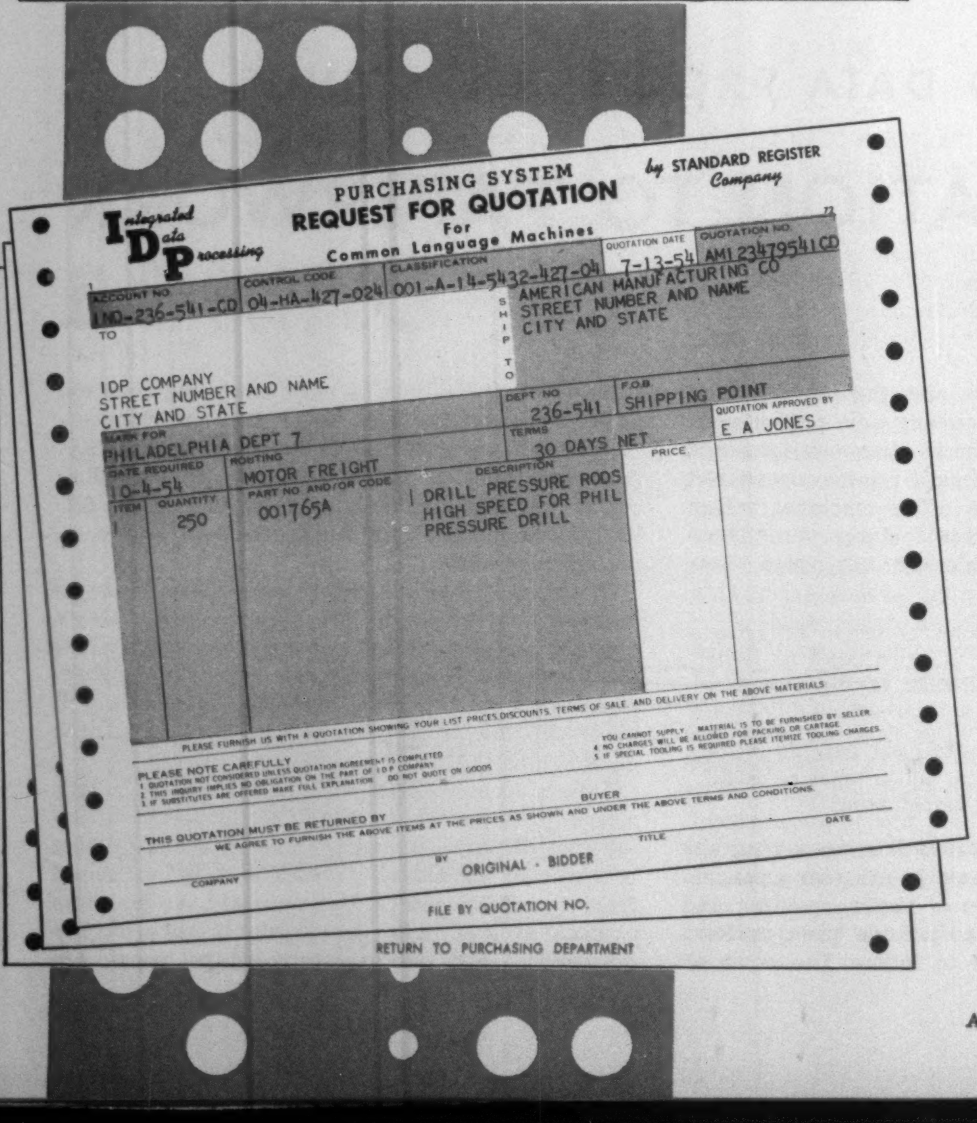
REQUISITIONER'S COPY

OPEN FILE COPY STOCK ROOM

APPROVAL COPY

REQUISITION SET

Fig. 1—This requisition set illustrates the use of a common language machine (Flexowriter) to write a request to purchasing. These three features are particularly significant: (1) Use of a prepunched "item tape" to insert repetitive data automatically; (2) insertion of variable data by operator using keyboard; and (3) punching of a common language tape for use in preparing request for quotation or purchase order forms. Typing in color areas of sample is inserted automatically by tape



Integrated Data Processing

PURCHASING SYSTEM
REQUEST FOR QUOTATION
For
Common Language Machines

by STANDARD REGISTER Company

72

QUOTATION DATE 7-13-54
QUOTATION NO. AM12347954ICD
ACCOUNT NO. IND-236-541-CD
CONTROL CODE 04-HA-427-024
CLASSIFICATION 001-A-14-5432-427-04
TO IDP COMPANY
STREET NUMBER AND NAME
CITY AND STATE
SHIP TO AMERICAN MANUFACTURING CO
STREET NUMBER AND NAME
CITY AND STATE
DEPT NO 236-541
F.O.B. SHIPPING POINT
QUOTATION APPROVED BY E A JONES
MARK FOR PHILADELPHIA DEPT 7
TERMS 30 DAYS NET
DATE REQUIRED 10-4-54
ROUTING MOTOR FREIGHT

ITEM	QUANTITY	PART NO AND/OR CODE	DESCRIPTION	PRICE
1	250	001765A	DRILL PRESSURE RODS HIGH SPEED FOR PHIL PRESSURE DRILL	

PLEASE FURNISH US WITH A QUOTATION SHOWING YOUR LIST PRICES DISCOUNTS, TERMS OF SALE, AND DELIVERY ON THE ABOVE MATERIALS

PLEASE NOTE CAREFULLY
1 QUOTATION NOT CONSIDERED UNLESS QUOTATION AGREEMENT IS COMPLETED
2 THIS INQUIRY IMPLIES NO OBLIGATION ON THE PART OF I.D.P. COMPANY
3 IF SUBSTITUTES ARE OFFERED MAKE FULL EXPLANATION DO NOT QUOTE ON GOODS YOU CANNOT SUPPLY. MATERIAL IS TO BE FURNISHED BY SELLER
4 NO CHARGES WILL BE ALLOWED FOR PACKING OR CARTAGE
5 IF SPECIAL TOOLING IS REQUIRED PLEASE ITEMIZE TOOLING CHARGES

BUYER

THIS QUOTATION MUST BE RETURNED BY

WE AGREE TO FURNISH THE ABOVE ITEMS AT THE PRICES AS SHOWN AND UNDER THE ABOVE TERMS AND CONDITIONS.

COMPANY BY TITLE DATE

ORIGINAL - BIDDER

FILE BY QUOTATION NO.

RETURN TO PURCHASING DEPARTMENT

REQUEST FOR QUOTATION

Fig. 2—Areas in color on this request for quotation form are typed automatically by the tape which was punched when requisition was written. The tape automatically stops the common language machine at the proper points so the operator can enter manually the vendor's name, address, quotation date, approved by and price

responsible for keeping an adequate supply on hand.

Under conventional or traditional methods, inventory control probably would have in file a "parts card" describing that item, containing such facts as the account number to which it is to be charged, code for the product in which it is used, part number, part name, and other such facts concerning that part. When use of that part caused the balance-on-hand to drop to the low limit, inventory control would initiate the purchase of an additional supply. Usual practice involves pulling the parts card from file, copying most or all the descriptive information onto a purchase requisition and forwarding the purchase requisition to the purchasing department.

Purchasing policy requires that three bids be secured so the purchasing department probably rewrites the same data on three requests for quotation, each of which will be addressed and sent to one of the eligible suppliers. When those bids are all received, the order will be awarded to one of the bidders by placing the same basic information upon a purchase order. When the parts arrive, much of the same information must appear again upon the receiving report describing their arrival for interested parties.

▶ Mechanization of Routine

Now let's see what integrated data processing can do to speed and simplify this routine. In considering this illustration, compare it to your own company's methods for handling this function, but keep an open mind while you're about it. The procedure to follow is directly applicable to many industrial operations, which may or may not include yours. No one method can be a universal solution, because problems and requirements of different companies are widely different. Consequently, don't condemn your present method because it lacks some of these ideas. Likewise, don't condemn this example because it appears to be unsuited to your own use. Instead, reflect upon the ideas illustrated by this example. You're likely to find at least one or two which could and should be adapted to your own use.

Now let's go back to the beginning of our hypothetical problem which started with the need for replenishing our stock of a purchased part. Remember that parts card? The data it contains must be used repeatedly—every time we order that part, as a matter of fact. Integrated data processing principles can help us to avoid the necessity for copying and recopying that information, by making these data self-perpetuating. Suppose, for example, that the parts card data were punched into a strip of common language tape, which was stored along with the parts card. In this case, the parts card might well be a folded card, forming an open sided pocket to contain the corresponding tape.

The document shown in *Fig.* 1 might be our purchase requisition form. Notice that certain areas shaded in blue contain the repetitive data describing the part involved. These are the areas which, by conventional methods, would be copied from the parts card onto the purchase requisition every time the part was needed.

▶ Data Distribution

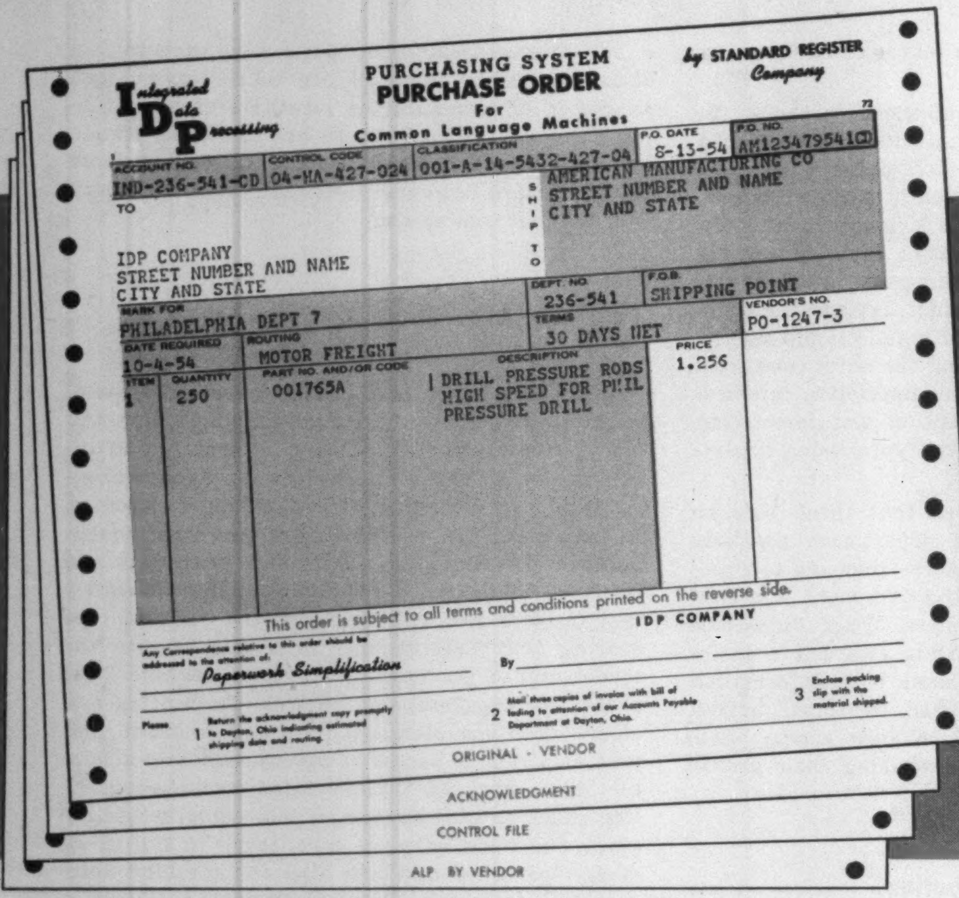
Under our integrated data processing system, however, that strip of common language tape will "copy" the information quickly, accurately and automatically. By providing the inventory control center with a tape-reading, tape-punching typewriter, we may mechanize the writing of purchase requisitions to a high degree. With such provisions and when a part is to be requisitioned, the inventory control clerk will pull from file the strip of tape bearing that part number, inserting it into the reader unit of the common language machine. That parts tape programs and controls the writing machine—inserting standard information about that part at a rate in excess of 500 characters per minute. Also, since the tape contains machine-controlling codes as well as data, it will advance and position the form to cause each entry to fall in its prescribed space and will stop the machine automatically at each point where variable information (such as *Date . . . Req. No. . . . Date Required,* etc.) is to be entered by manual operation of the keyboard by the operator.

In this way, our purchase requisition is completed . . . partly by manual keystrokes which appear in the unshaded areas but largely by automatic, high-speed typing controlled by the tape and represented by information appearing in the blue shaded areas of the finished form.

While all this was going on, the common language machine was busily punching a new complete tape, which included *all* information appearing on the requisition, both the manually typed variable items and the automatically typed standard items. Upon completion of the requisition, the parts tape is refiled for later reuse. The new, complete tape accompanies the requisition to purchasing where it will help to mechanize their part of the job.

Under this concept, our purchasing department is also equipped with a tape-reading, tape-punching typewriter. When our requisition arrives, accompanied by its related common language tape, purchasing can now issue invitations to bid to three or more vendors, without copying a single keystroke. Inserted into the reader of purchasing's common language typewriter, the requisition tape will repeat its story through that machine at the same 500-plus characters per minute, stopping only to let the operator manually type each eligible bidder's name and address.

The finished request for quotation would look like the form in *Fig.* 2. Again, the typing in blue



Integrated Data Processing

PURCHASING SYSTEM
PURCHASE ORDER
For
Common Language Machines

by STANDARD REGISTER Company

72

ACCOUNT NO. IND-236-541-CD
CONTROL CODE 04-MA-427-024
CLASSIFICATION 001-A-14-5432-427-04
P.O. DATE 8-13-54
P.O. NO. AM123479541CD

TO
IDP COMPANY
STREET NUMBER AND NAME
CITY AND STATE

SHIP TO
AMERICAN MANUFACTURING CO
STREET NUMBER AND NAME
CITY AND STATE

DEPT. NO. 236-541
F.O.B. SHIPPING POINT
MARK FOR PHILADELPHIA DEPT 7
TERMS 30 DAYS NET
VENDOR'S NO. PO-1247-3
DATE REQUIRED 10-4-54
ROUTING MOTOR FREIGHT

ITEM	QUANTITY	PART NO. AND/OR CODE	DESCRIPTION	PRICE
1	250	001765A	DRILL PRESSURE RODS HIGH SPEED FOR PHIL PRESSURE DRILL	1.256

This order is subject to all terms and conditions printed on the reverse side.

IDP COMPANY

Any Correspondence relative to this order should be addressed to the attention of:
Paperwork Simplification

By ____________

Please
1 Return the acknowledgment copy promptly to Dayton, Ohio indicating estimated shipping date and routing.
2 Mail three copies of invoice with bill of lading to attention of our Accounts Payable Department at Dayton, Ohio.
3 Enclose packing slip with the material shipped.

ORIGINAL - VENDOR

ACKNOWLEDGMENT

CONTROL FILE

ALP BY VENDOR

PURCHASE ORDER IN QUADRUPLICATE

Fig. 3—Areas indicated
color on this purchase or
form are typed automatica
from the common langua
tape, which was punched
the same time the request f
quotation was being typ
The tape automatically sto
the common language m
chine so that the opera
can enter the balance of t
information manually.
this purchase order is bei
typed on the sending Tel
typewriter, the receiving r
port is being typed on th
receiving Teletypewriter,
the receiving department

shaded areas was inserted automatically while only the typing in unshaded areas was inserted manually. Since only one eligible vendor's name is desired on each request for quotation, the process is repeated for each potential supplier involved, in this example. By a somewhat more complex form design, several such requests could be combined into one form set for further simplification, but would involve more detailed explanation.

As in the case of the requisition-writing operation, purchasing's common language machine would produce a complete new common language tape as an automatic by-product of typing each request for quotation. Thus, after writing and mailing three such requests, purchasing would have in file its copy of each request—together with a common language tape of that request.

The requisition tape, having served its purpose by providing the means for mechanizing the writing of requests for quotation, would be destroyed at this point. Other possible uses of that tape exist and will be mentioned later, but to simplify this explanation, let's just forget the requisition tape for the present.

Eventually, each bidder will return his quotation, at which time purchasing will determine which one is to get the order. File copies and tapes representing unsuccessful bidders would be destroyed, while tape corresponding to the successful bidder would be used to prepare the purchase order, *Fig.* 3.

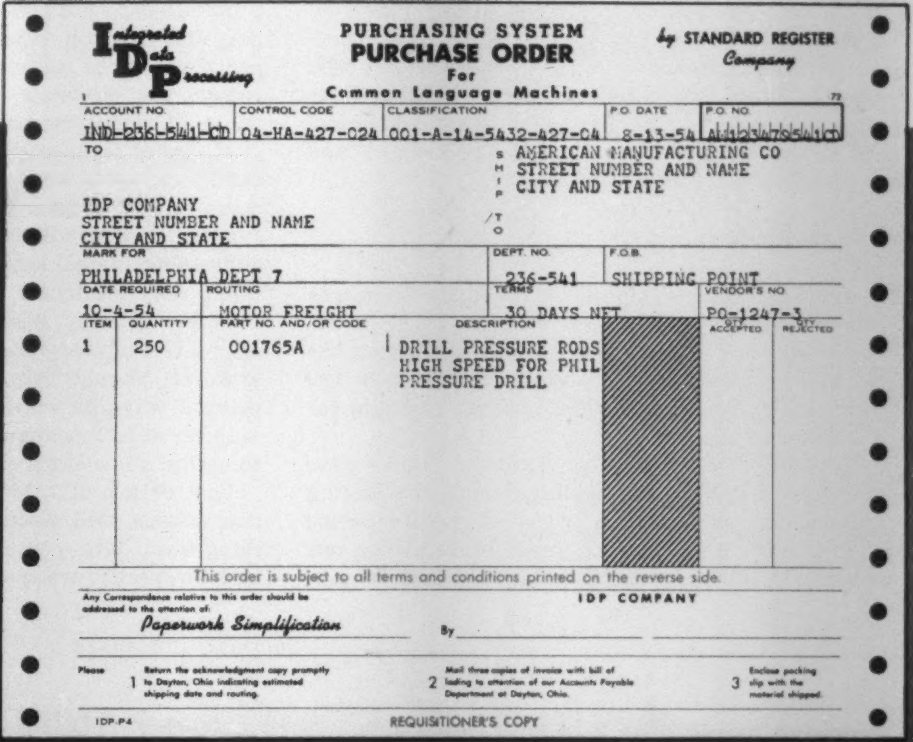
Communication of Data

Let's do a little more assuming at this point. Let's assume that we are a widely-scattered organization, with our material control, purchasing, and receiving departments all remotely located from each other—anywhere from ten to a thousand miles apart. All three of these departments are vitally interested in our parts-ordering project because each has a definite share in the responsibility. For that and other reasons, these key points are linked by Teletypewriter circuits, thus insuring that each has prompt, complete advice of each transaction.

The Teletypewriter, being another of the common language machines, gives purchasing a chance to kill several birds with that piece of tape which was a by-product of requesting a bid from the successful vendor. Purchasing now feeds that tape into the reader of its Teletypewriter machine, where it operates the circuit automatically in the same manner discussed earlier. This writer stops automatically at the points where limited variable data are to be inserted by manual operation of the keyboard. Aside from those few manual keystrokes, the purchase order is typed automatically by the tape.

At the same time that purchasing gets a finished purchase order from its Teletypewriter, the receiving Teletypewriter, located miles away in the ma-

REQUISITIONER'S COPY



Integrated Data Processing

PURCHASING SYSTEM
PURCHASE ORDER
For
Common Language Machines

by STANDARD REGISTER Company

1 72

ACCOUNT NO.	CONTROL CODE	CLASSIFICATION	P.O. DATE	P.O. NO.
IND-236-541-CD	04-HA-427-024	001-A-14-5432-427-04	8-13-54	A4123479541CD

TO
IDP COMPANY
STREET NUMBER AND NAME
CITY AND STATE

SHIP/TO
AMERICAN MANUFACTURING CO
STREET NUMBER AND NAME
CITY AND STATE

MARK FOR	DEPT. NO.	F.O.B.	
PHILADELPHIA DEPT 7	236-541	SHIPPING POINT	
DATE REQUIRED	**ROUTING**	**TERMS**	**VENDOR'S NO.**
10-4-54	MOTOR FREIGHT	30 DAYS NET	PO-1247-3

ITEM	QUANTITY	PART NO. AND/OR CODE	DESCRIPTION		QTY. ACCEPTED	QTY. REJECTED
1	250	001765A	DRILL PRESSURE RODS HIGH SPEED FOR PHIL PRESSURE DRILL	▨		

This order is subject to all terms and conditions printed on the reverse side.

Any Correspondence relative to this order should be addressed to the attention of:
Paperwork Simplification

IDP COMPANY
By ____________________ ____________________

Please
1 Return the acknowledgment copy promptly to Dayton, Ohio indicating estimated shipping date and routing.
2 Mail three copies of invoice with bill of lading to attention of our Accounts Payable Department at Dayton, Ohio.
3 Enclose packing slip with the material shipped.

IDP-P4 REQUISITIONER'S COPY

g. 4 — This requisitioner's ppy is typed in the stock oom simultaneously with the yping of the receiving report s it is teletyped to the re- eiving department. Both orms are typed on receiving eletypewriters, actuated by he sending machine over which the purchase order is eing typed

terial control office, is producing a copy of that order, *Fig*. 4, confirming that material control's requisition has been received and acted upon, and advising vendor name and order number involved.

In still another distant location, a third Teletypewriter located in the designated receiving department is producing a receiving report form, *Fig*. 5, for use when the shipment arrives. Simultaneously, the receiving department Teletypewriter equipment is producing the same data in the form of still another common language tape. Between the receiving document thus produced, and the corresponding strip of tape, the receiving department is prepared to record and report the arrival of that shipment with the least possible effort and delay.

Our specimen order calls for 250 of the part involved. If the vendor ships the entire quantity in the first shipment, receiving merely adds the necessary notations to the prewritten receiving report, distributes the copies and the cycle is complete. If the vendor delivers by means of several partial shipments, however, receiving can avoid repetitive writing of partial receiving reports by taking advantage of the common language tape they have filed with the receiving report. By inserting this tape into the reader of their Teletypewriter, receiving may have partial receiving reports typed automatically, except for manual insertion of *Date Received . . . Quantity Received . . .* and other such variables pertaining to each shipment. With the recording of each such partial shipment, receiving also notifies both the inventory control and purchasing departments of each new development instantaneously.

Thus we have completed the transaction from detection of an item short in stock through issuance of a purchase requisition, requesting eligible vendors to bid, issuing a purchase order, and recording arrival of the stock without requiring clerical transcription of a single character. All has been achieved by simple application of the integrated data processing concept. In effect, we have set these various machines to talking to themselves and to each other by means of common language tapes, which all are capable of reading. In so doing, we have removed many human hands from this chain of events. With reduction of human participation comes the related reductions of errors, costs and delays.

In reviewing this example, we've skipped lightly over many details involved; we cannot hope to explore all of them to our complete satisfaction in a reasonable space. There are several points which deserve additional comment, however.

You may have noticed, for example, that while certain of these forms were described as being written largely from by-product tapes, they differed rather widely in design, appearance and content. The only general explanation of these apparently impossible occurrences lies in the fact that the development, not the operation but the initial planning and creation of such systems, require infinite attention to details of forms design and construction as well as machine programming and operation. Such technical details need not alarm any who hope to apply integrated data processing to their own paperwork problems, since skilled technical assistance is available for such development and application to specific problems.

▶ By-Product Tapes

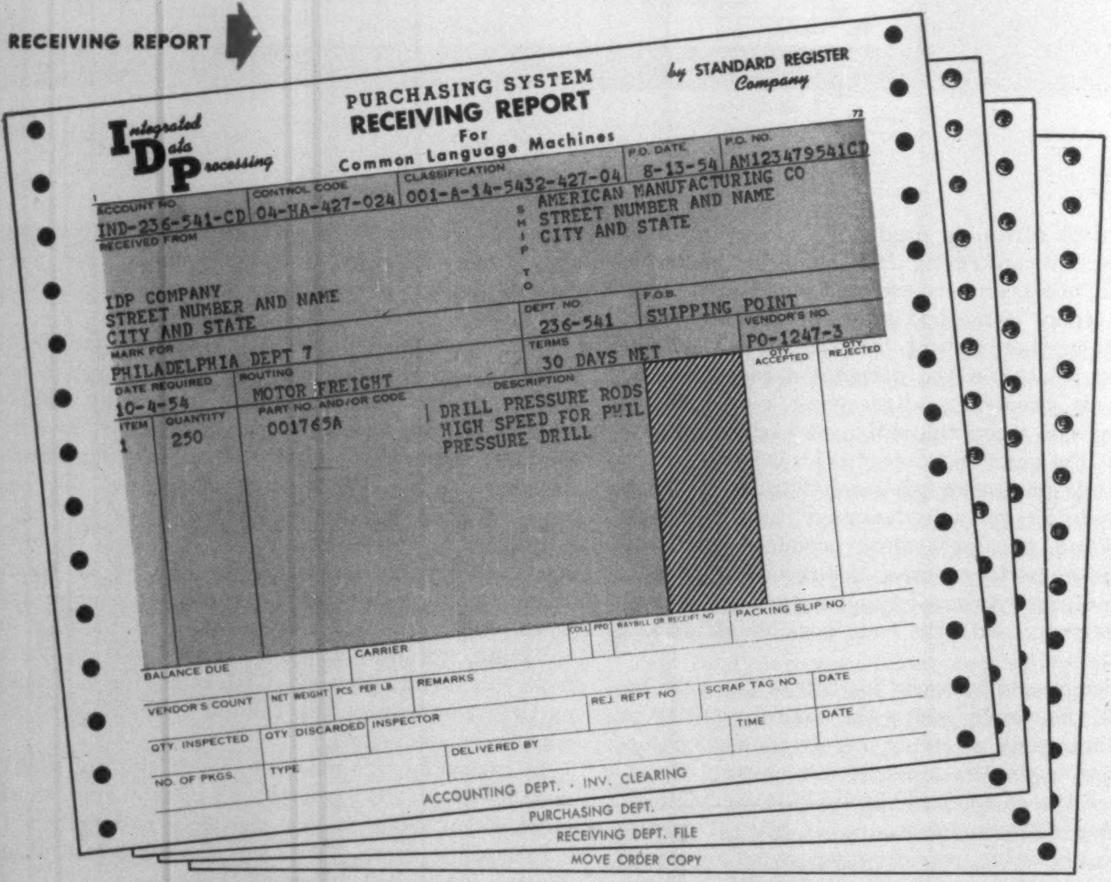
Another point of major significance concerns other uses of by-product common language tapes. Referring back to our example, you'll recall that the by-product tape from the requisitioning step was discarded after it had served to write requests for quotation automatically.

Instead of destroying it, we might well have passed it along to our punched card accounting (tabulating) department, where it could be used to create a file of punched cards representing our on-order parts account. These cards could be produced automatically by passing such a tape through a tape-to-card converter. In the same general manner, the tape or tapes resulting from receipt of parts might be converted into punched cards to relieve the on order account and to charge the on hand inventory account automatically.

At any of these steps involving common language machines, by-product tapes may be produced to serve any of several purposes including automatic typing, wire transmission, preparation of metal addressing plates, conversion to punched cards, or input into electronic computer systems.

This relatively simple example has illustrated only a few of these possibilities. Its very simplicity, however, should help to make more obvious the general ways in which integrated data processing may serve to mechanize paperwork, thus bring automation a few steps closer.

Last article of this series, to appear in the February issue, will discuss common situations where integrated data processing is profitable and will include specific areas of application.



RECEIVING REPORT

Integrated Data Processing

PURCHASING SYSTEM
RECEIVING REPORT
For
Common Language Machines

by STANDARD REGISTER Company

73

P.O. DATE 8-13-54
P.O. NO. AM123479541CD
ACCOUNT NO. IND-236-541-CD
CONTROL CODE 04-HA-427-024
CLASSIFICATION 001-A-14-5432-427-04

SHIP TO
AMERICAN MANUFACTURING CO
STREET NUMBER AND NAME
CITY AND STATE

RECEIVED FROM
IDP COMPANY
STREET NUMBER AND NAME
CITY AND STATE

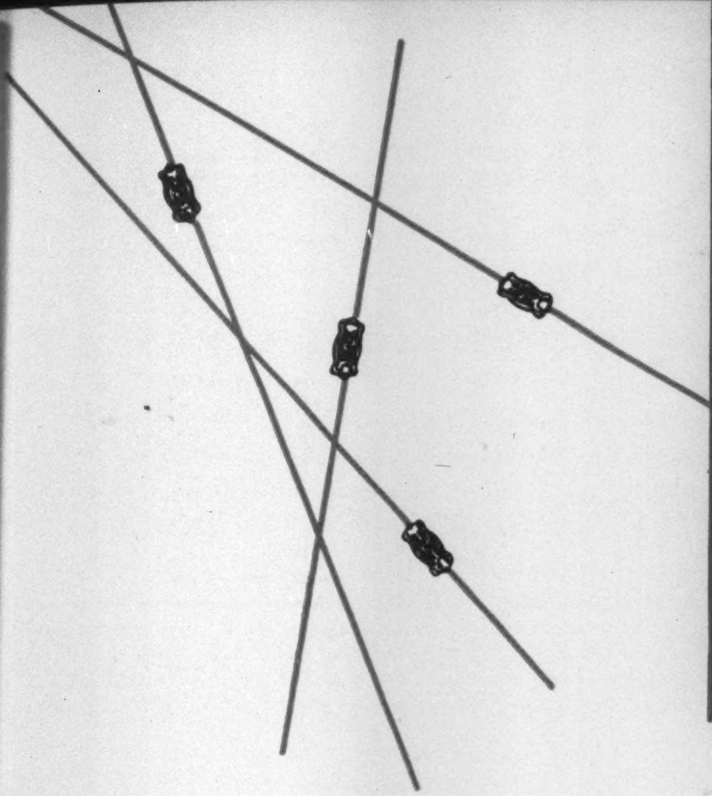
DEPT. NO. 236-541
F.O.B. SHIPPING POINT
VENDOR'S NO. PO-1247-3
MARK FOR PHILADELPHIA DEPT 7
TERMS 30 DAYS NET
DATE REQUIRED 10-4-54
ROUTING MOTOR FREIGHT

ITEM	QUANTITY	PART NO. AND/OR CODE	DESCRIPTION	QTY. ACCEPTED	QTY. REJECTED
1	250	001765A	DRILL PRESSURE RODS HIGH SPEED FOR PHIL PRESSURE DRILL		

BALANCE DUE
CARRIER
COLL
PPD
WAYBILL OR RECEIPT NO
PACKING SLIP NO.
VENDOR'S COUNT
NET WEIGHT
PCS. PER LB.
REMARKS
REJ. REPT. NO
SCRAP TAG NO.
DATE
QTY. INSPECTED
QTY. DISCARDED
INSPECTOR
TIME
DATE
NO. OF PKGS.
TYPE
DELIVERED BY

ACCOUNTING DEPT. - INV. CLEARING
PURCHASING DEPT.
RECEIVING DEPT. FILE
MOVE ORDER COPY

Fig. 5—This form was typed automatically on the Teletypewriter in the receiving department at the same time the purchase order was being typed on the sending Teletypewriter. Simultaneously, and as an automatic by-product, another complete common language tape is produced for further mechanization or related clerical operations such as partial receivals, automatic preparation of inventory punched cards, input into electronic computers, and other processing by means of common language machines



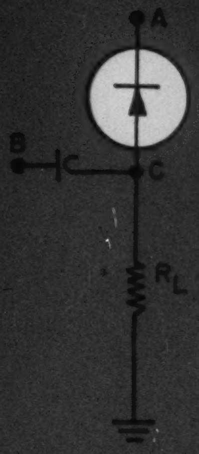


Fig. 1—Basic diode amplifier circuit developed at the National Bureau of Standards. Input signal is at B, output at C. One-megacycle radio frequency or "clock" power is applied to point A

PROMISING ELECTRONIC COMPONENTS . . .

DIODE AMPLIFIERS

What is a diode and what circuitry can be devised to make its characteristics useful? Coupled with simple elements, amplification at high frequencies can be obtained with these commercially available, semiconducting devices

RESEARCH on application of semiconducting diodes has led to development of a new class of amplifiers that utilizes the reverse transient phenomenon of these two-element rectifying devices. Devised by the National Bureau of Standards, the diode amplifier—using no vacuum tubes and achieving power gains of up to ten per stage—promises important application in the future design of high-speed electronic equipment, *Fig.* 1. For example, it may be used as a pulse repeater stage in varied types of flip-flop circuits, or as a wide-band, flat-response amplifier. Because suitable diodes are now in regular production, commercial applications are practical at the present time. Future improvement in the manufacture of diodes may make the principle useful for amplification even at microwave frequencies.

Basic requirement of the diode amplifier is that it be supplied with power from a radio frequency source the same or higher than the modulating signal frequency. This requirement puts the circuit in the same category as magnetic and dielectric amplifiers.

A semiconductor diode of the germanium or silicon type has two static conditions:

1. Forward conducting state, characterized by high conductivity.
2. Reverse conducting state, characterized by low conductivity.

The forward state is achieved by applying a biasing voltage so that the anode is more positive than the cathode; the reverse state by applying voltage of opposite polarity. Forward voltage acts to create a steady supply of "carriers" of current within the semiconducting material, maintaining a condition of high conductivity. Carriers are not created during the reverse static state. If voltage applied

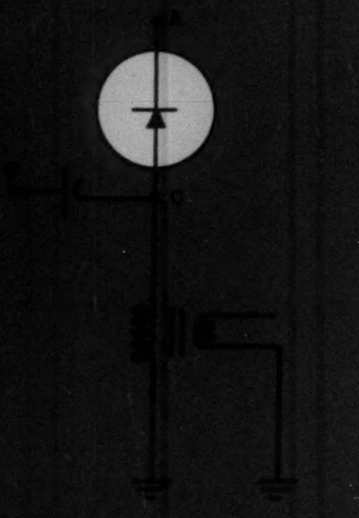


Fig. 2—Similar in operation to the basic diode amplifier, this circuit, the transformer-diode coupled amplifier, provides current gain by use of a transformer

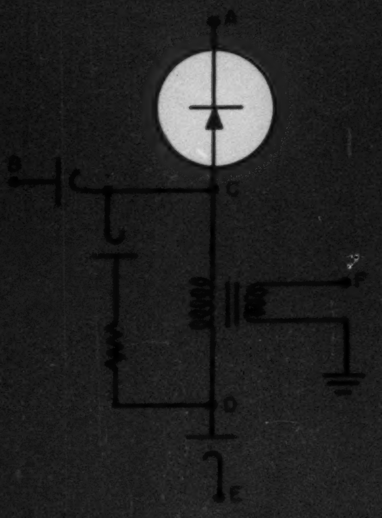


Fig. 3—Addition of a capacitor and resistor between transformer and ground aids in transformer primary recovery between pulses, on a many-pulse basis

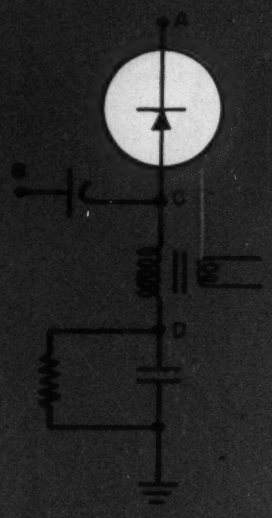


Fig. 4—An improvement which permits the transformer to recover on a pulse-to-pulse basis is achieved by driving point *E* with a clock voltage 180 degrees out of phase with the power supply clock

to the diode is switched quickly from forward to reverse, a transient phenomenon occurs in which large reverse current flows for an appreciable time after switching takes place, and decays until the static reverse state is reached. Transient current occurs because the carriers which were present due to the forward voltage remain available to be swept out by application of reverse voltage. The carriers do not remain indefinitely during a period of delay between cessation of forward voltage and application of reverse voltage; instead, their number decreases with time during this period.

▶ Diodes and Transistors

Although amplification in the diode is not a continuous phenomenon, the action may be likened to the way in which amplification is obtained in a transistor—the emitter can be regarded as a diode existing in the forward conducting state, and the collector as a diode in the reverse state. If any carriers created by the forward biased diode are transported to the vicinity of the reverse biased diode, a larger current than the static current will flow in the latter diode.

Voltage on the emitter of a transistor produces current which creates carriers that change the current in the collector, which in turn changes the voltage across the collector. In the case of a junction transistor used in the common base circuit, the collector current is almost equal to the emitter current, so that power gain is effectively determined by the ratio between the forward and the reverse resistances. Thus, power gain is obtained by a transfer of current from one circuit of low impedance to another circuit of high impedance.

The diode amplifier obtains its power gain in a similar manner, except that one electrode serves as both emitter and collector, but at different times. During half of the cycle, the anode is more positive than cathode, and the anode acts as the emitter of a junction transistor; during the other half-cycle, the anode acts like a collector. When it is an emitter, it injects carriers into the germanium with only a small applied forward voltage, at low impedance level. When it is a collector, the anode withdraws these same carriers, but only by applying a much higher voltage—at a higher impedance level.

▶ Resistance-Diode Amplifier

Simplest form of diode amplifier is the resistance-diode coupled circuit, *Fig.* 1. The waveform applied to point *A* is from a one-megacycle power source, chosen for experimental purposes because its one-microsecond period is approximately equal to the carrier decay time in diodes which have been most extensively used. The radio-frequency supply, or "clock", not only acts as the power source but also as the switch which controls two separate phases of the amplification cycle—the intake of signal power into the amplifier diode (injection of carriers) and the output of amplified power (decay of carriers). As an analogy, operation of the diode amplifier may be likened to that of a gasoline engine, where fuel is injected during one part of the cycle and fired at a later part.

When there is no input at point *B,* there is no output because of the high impedance of the ampli-

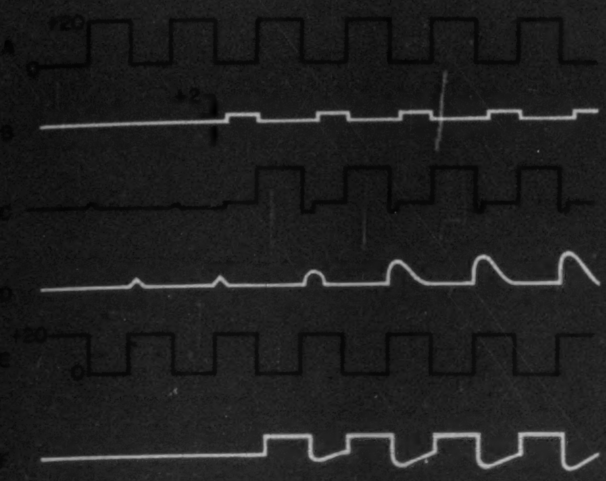


Fig. 5—Waveforms at various points in the circuit of Fig. 4. Clock *A* is shown here as a square wave although a half-wave rectified sine wave can also be used. *B* and *F* are respectively input and output voltage signals

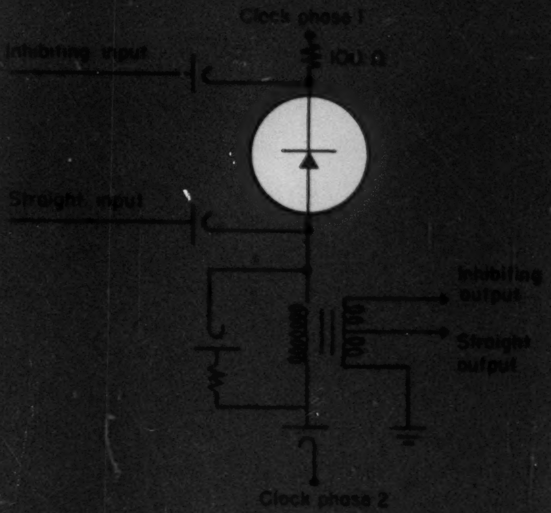


Fig. 6—Computer pulse repeater stage which uses the NBS diode amplifier and an inhibiting gate. Delay lines are sometimes used to accurately time inhibiting pulses

fier diode. A small voltage spike does appear in the output due to small capacitance of the diode. This, however, can be decreased by paralleling the load resistor with a capacitor for capacitance division. When point *B* is raised to plus two volts while the clock is at zero volts, carriers are injected into the diode by current in the direction *BCA*. For a short time the diode presents a very low impedance to the reverse voltage applied by the clock. Since this impedance is low compared to the load resistor, most of the clock voltage appears across the resistor.

Power gains of about ten (average output power divided by average input power) have been measured using a 20-volt clock. The only limitation on the amplitude of the clock voltage is that it not exceed reverse breakdown voltage. The requirement on the clock supply is rather severe in that during the time that the clock is at zero volts, its impedance should be very low, so that as much of the available input signal power as possible will be across the diode and not divided between the diode and the clock source. In practical applications, clock voltage may be distributed as a full sine wave and then half-wave rectified near point of use.

▶ Transformer-Diode Amplifier

Some circuit element which transforms voltage gain to current gain is essential to most circuits using the diode amplifier because there is no average current gain in diodes that have been used thus far in Bureau experiments. The transformer-diode coupled circuit, shown in *Fig.* 2, achieves current gain through a step-down transformer. Its operation is similar to the resistance-diode coupled amplifier. In this form, the circuit is suitable for amplification of low duty cycle pulses but will not operate at high duty cycles because stored energy in the magnetic circuit will not permit the transformer primary to recover or "fly back". A solution to this difficulty is obtained through addition of a capacitor and resistor between the transformer primary and ground, shown in *Fig.* 3. This circuit has the disadvantage that flyback requirements of the inductance are satisfied only on a many-pulse basis and not on a pulse-to-pulse basis. The many-pulse average can also cause trouble in turning off the stage at the end of a train of pulses.

If the end of the transformer primary, point *E*, *Fig.* 4, were to be driven by a clock voltage 180 degrees out of phase with the power supply clock, the flyback requirements would be satisfied on a pulse-to-pulse basis because point *D* would be allowed to fly back or not as necessary. During the time the clock pulse is on and when point *A* is up, point *E* is at ground and conventional current flows through the path *ACDE*. After the power clock pulse, point *E* is driven positive by the other clock phase, disconnecting the diode between *D* and *E*. At the same time, point *B* may be charging the diode amplifier for the next power clock pulse. The series diode and resistor between *C* and *D* provide critical damping of flyback. Waveforms at various points in the circuit are shown in *Fig.* 5.

Further development of the diode-amplifier concept leads to design of a complete pulse repeater stage for application in electronic digital computers. The circuit shown in *Fig.* 6 satisfies essential requirements. It is a combination of the trans-

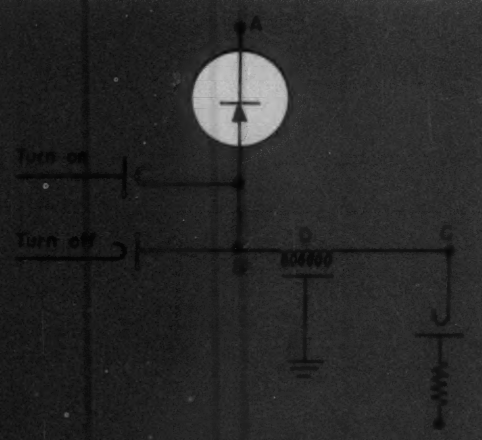


Fig. 7—Flip-flop circuit which uses the NBS diode amplifier. This circuit stores energy between clock pulses in the delay line *D*.

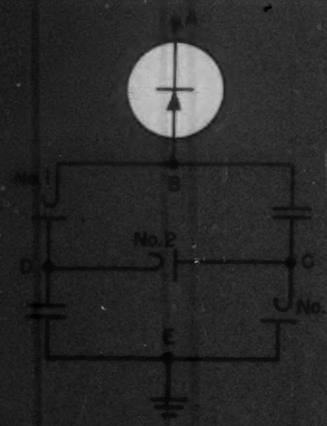


Fig. 8—Current-doubler flip-flop circuit. Condensers are charged in series and discharged in parallel

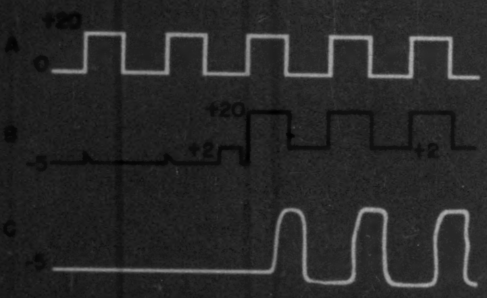


Fig. 9—Waveforms of the circuit in Fig. 8 As in the circuit of *Fig. 7*, the oscillating state is started by *raising* point *B* to plus two volts

former-diode coupled amplifier, and an inhibiting gate. Delay lines may be used but can be avoided in most cases, since carriers in the amplifier diode store information. It may be necessary, however, to use some delay lines to accurately time the inhibiting pulses.

Flip-Flop Circuits

The diode amplifier can be used as the basis for a variety of dynamic flop-flop circuits—oscillators which can remain stable either in an oscillating or a nonoscillating state. The circuit shown in *Fig.* 7 stores energy between clock pulses in a delay line. The oscillating state is started by raising point *B* to plus two volts to inject carriers. On the clock pulse immediately following, point *B* is raised to plus 20 volts, and the pulse travels down the delay line. At point *C* it experiences an open circuit and so is returned in the same polarity at the proper time to inject more carriers into the amplifier diode. The delay line also serves as an impedance-matching device or it can provide the necessary current. In injecting carriers into the amplifier diode, the delay line faces very low impedance so that some energy is returned down the line for a third travel, this time negative. At point *C*, however, the negative pulse is matched and absorbed; if it were not, it would travel back down the line a fourth time and prevent the next carrier injection.

Another flip-flop circuit, shown in *Fig.* 8, is a current-doubler type. Essentially, it charges two capacitors in series and then discharges them in parallel. If point *B* is pulled positive, diodes 1 and 3 are cut off; current flows through the path *BCDE*, charging the two capacitors in parallel. When point *B* becomes negative, diode 2 is cut off, and current flows through the paths *EDB* and *ECB*, discharging the capacitors in parallel. When used with the germanium diode amplifier, this circuit makes a flip-flop whose applied frequency can be varied over a very wide range. Many other flip-flop circuits have been developed, some of which are even simpler and less expensive than these described here.

Higher Speed Circuitry

Silicon junction diodes have a much faster transient recovery than germanium junction diodes, and therefore can be used in faster circuits. In experiments made to study usefulness of the silicon diode as an amplifier, a current-doubler type of flip-flop operated satisfactorily with a clock frequency of 25 megacycles; the circuit exhibited start-stop time of about 100 millimicroseconds. It should be possible to achieve much higher frequencies by using diodes with even shorter decay times. This promises to provide very fast, practical circuitry for future use in electronic computers and many other useful applications as well.

Sixth of a series, AUTOMATION presents another section of the ASME standard "Automatic Control Terminology"; an original work of the Terminology Committee of the Industrial Instruments and Regulators Division. It is hoped these data sheets will assist in furthering the adoption of a standardized language in the field of automatic control

ADJUSTMENTS OF CONTROLLER ACTION

601. NEUTRAL ZONE is a predetermined range of values of the controlled variable in which no change of position of the final control element occurs.

Neutral zone is commonly expressed in per cent of controller scale range. A neutral zone is employed in some types of floating controller action.

602. DIFFERENTIAL GAP, applying to two-position controller action, is the smallest range of values through which the controlled variable must pass in order to move the final control element from one to the other of its fixed positions.

Differential gap is commonly expressed in units of the controlled variable or per cent of controller scale range.

603. PROPORTIONAL BAND, applying to proportional-position controller action, is the range of values of the controlled variable which corresponds to the full operating range of the final control element.

Proportional band is commonly expressed in units of the controlled variable or per cent of controller scale range.

604. FLOATING SPEED (applying to single or multi-speed controller action) is the rate of motion of the final control element.

Floating speed is commonly expressed in per cent of full range motion per minute.

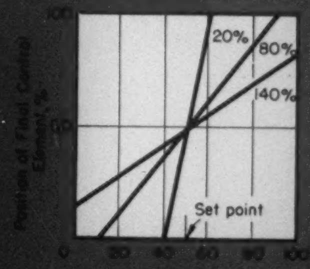
605. FLOATING RATE (applying to proportional-speed floating controller action) is the ratio of the speed of the final control element to the deviation.

606. RESET RATE (applying to proportional plus reset controller action and proportional plus reset plus rate controller action) is the number of times per minute that the effect of the proportional-position action upon the final control element is repeated by the proportional-speed floating action.

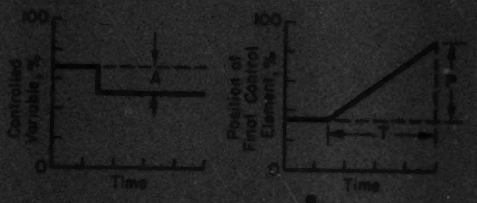
Reset rate is commonly expressed as a number of "repeats" per minute. It is determined by dividing (1) the travel of the final control element in one minute due to the effect of proportional-speed floating action by (2) the travel due to the effect of proportional-position action, with the same deviation in both cases.

607. RATE TIME (applying to proportional plus rate controller action and proportional plus reset plus rate controller action) is the time interval by which the rate action advances the effect of the proportional-position action upon the final control element.

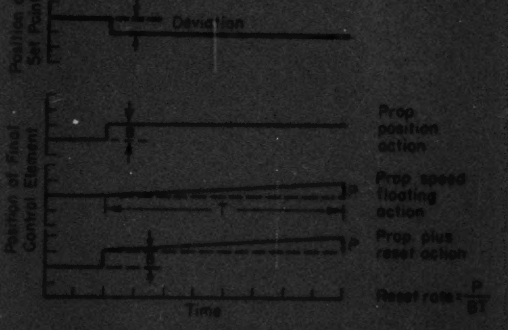
Rate time is commonly expressed in minutes. It is determined by subtracting (1) the time required for a selected motion of the final control element, due to the combined effect of proportional-position plus rate actions, from (2) the time required for the same motion due to the effect of proportional-position action alone, with the same rate of change of the controlled variable in both cases.



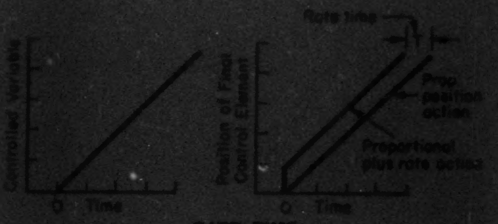
PROPORTIONAL BAND ADJUSTMENTS


100
Controlled Variable, %
A
0
Time
100
Position of Final Control Element, %
P
T
0
Time

FLOATING RATE = $\frac{P}{AT}$


Position of Set Point
Deviation
Position of Final Control Element
Prop position action
B
Prop speed floating action
P
T
Prop plus reset action
P
B
Time
Reset rate = P/BT

RESET RATE


Controlled Variable
0
Time
Rate time
T
Position of Final Control Element
Prop position action
Proportional plus rate action
0
Time

RATE TIME

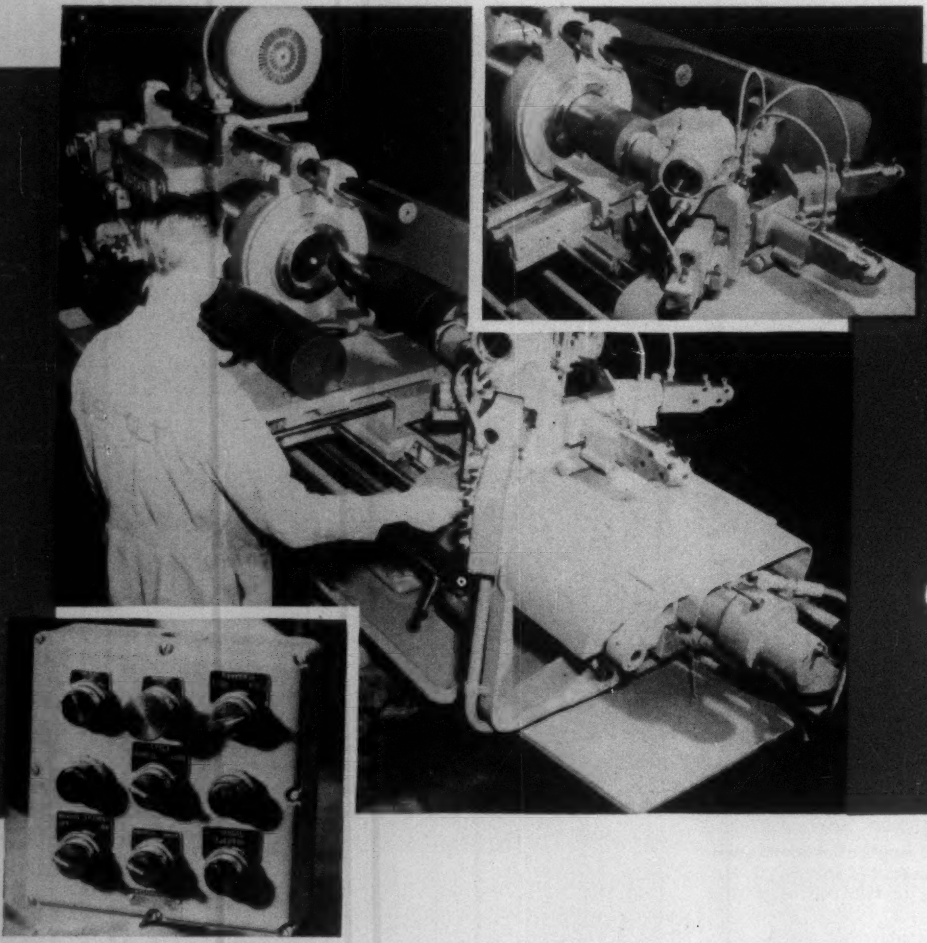
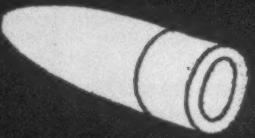
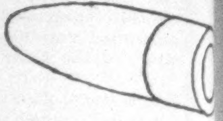


Fig. 1—By combining automatic loading and unloading with the regular machining cycle, two Gisholt 2F Fastermatic automatic lathes equipped with special hydraulically-operated loading shuttles speed the machining of base and nose ends of these shell bodies. Operator actuates pushbutton controls to traverse finished shell to rear of machine and conveyor (not shown) and to bring new workpiece to position for base-end machining





MACHINING SHELLS

Simplified automatic workpiece handling increases turret lathe production

AUTOMATIC HANDLING and positioning in most instances can improve production rates of metalworking machines more so than can attempted increases in machine cycling speed. Loading shuttles provide fuller utilization of machine productivity by making the loading and unloading functions part of the machine automatic cycle. Equipment works more, waits less.

Manufacture of steel shell bodies has been automated with the aid of simplified handling and chucking on Gisholt Fastermatic automatic turret lathes, *Fig.* 1, using special double-cradle hydraulic loading shuttles. One lathe machines the base-end of 8-inch steel shell bodies, another machines the nose-end.

Machining operations on either end of the shell are similar. In production, each machining cycle on the base-end starts with a freshly machined part on the rear cradle of the shuttle. The hexagonal turret carriage is in its furthermost position from the collet with station No. 1 facing the spindle. The shuttle is back towards the turret carriage so that the workpiece can clear the collet when moved transversely to the rear of the machine. After the operator loads a rough warkpiece onto the front cradle, the shuttle moves across the lathe to bring the new workpiece in line with the spindle centerline and the finished workpiece to the rear for removal by conveyor. The turret cycle starts with the carriage moving forward,

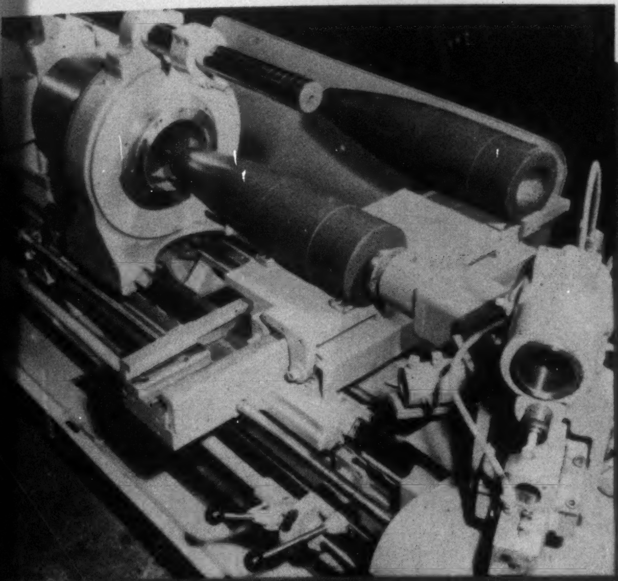


Fig. 2—Hexagon turret carriage moves forward carrying shuttle up to collet and positioning shell body in open jaws of the collet with pusher bar

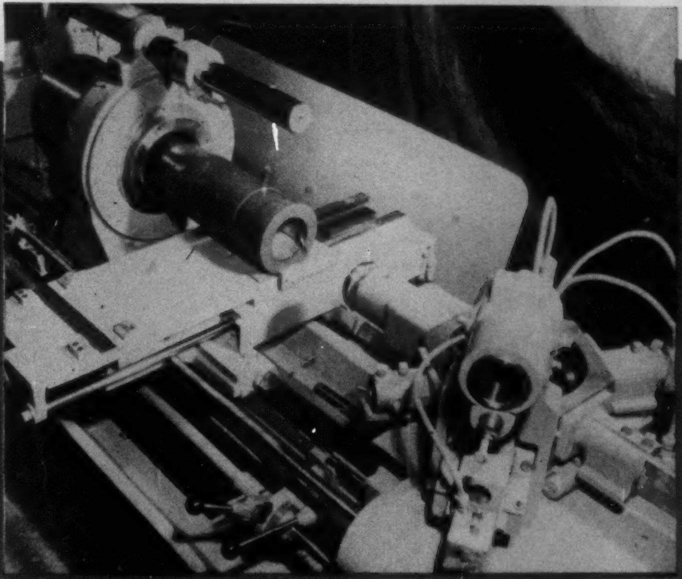
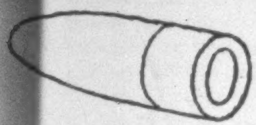
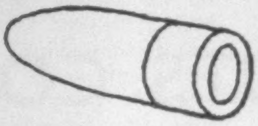


Fig. 3—As the ejected shell hits the plate stop, it carries the shuttle back until the shell clears the collet. Front cradle is in loading position





pushing the shuttle to the face of the collet. At the same time a pusher bar mounted on turret station No. 1 pushes the rough workpiece into the collet for chucking, *Fig.* 2.

After the piece is chucked and the turret carriage reverses to index to station No. 2, the spindle begins to rotate. Tools on turret stations No. 2 through 6 automatically index and feed into the workpiece to bore, counterbore and chamfer the base end of the shell body. While the machine is going through the automatic machining cycle, the previously finished piece is transferred from the rear cradle of the shuttle to a conveyor at the rear of the machine.

The automatic machining cycle is completed when the turret indexes back to station No. 1. Then the shuttle moves transversely across the bedways to the front of the machine. When completely forward it trips a limit switch which opens the collet chuck jaws releasing the part. A hydraulic ejector pushes the finished piece out of the collet onto the rear cradle of the shuttle, and as the shell is ejected it hits a stop plate mounted on the shuttle. Shell and shuttle are moved back towards the turret carriage until the shell clears the collet completely, *Fig.* 3.

While the front cradle is in forward position a rough workpiece from the front conveyor is loaded onto the shuttle. Pushbutton control from the master panel transverses the finished shell to the rear of the machine bringing the new, rough workpiece into position for chucking. Base-end machining cycle is ready to start over again.

Machining operations on the nose-end of these shell bodies follow a similar sequence. The shuttle, however, remains in a position next to the face of the collet and does not move longitudinally as in the base-end machining operation. When a finished piece is ejected from the collet chuck onto the rear cradle of the shuttle, a new part is placed on the front cradle. After this part is moved and chucked, the turret stations index through the automatic machining cycle to bore and chamfer the inside diameter of the shell nose and cut an annular ring around its outside periphery.

Master control panels give operators control of these special automatic lathes throughout the cycle. Pushbuttons and limit switches control starting, stopping, chucking, spindle rotation, shuttle movements, workpiece ejection, and permit manual or automatic cycling of the machine when setting up or changing tools. Location of all controls on a single panel eliminates waste motion and contributes to the overall increase in production.

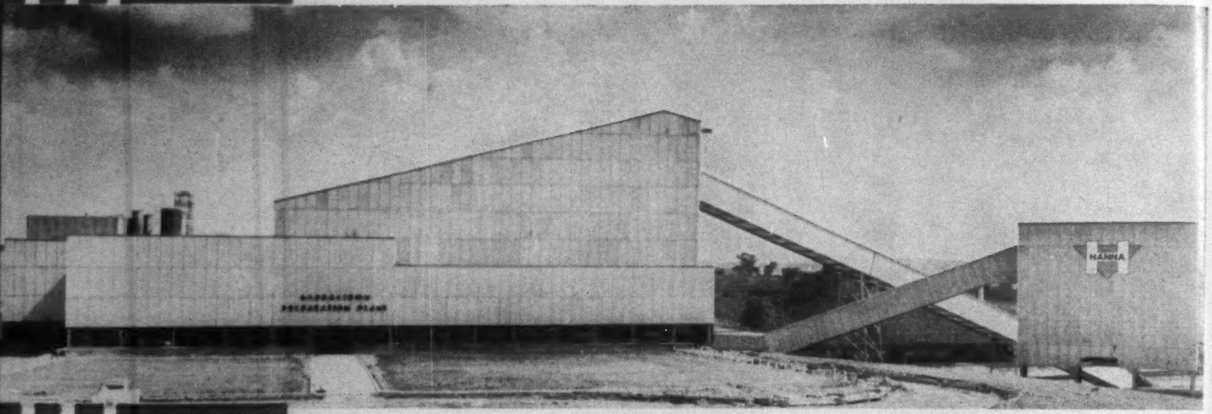
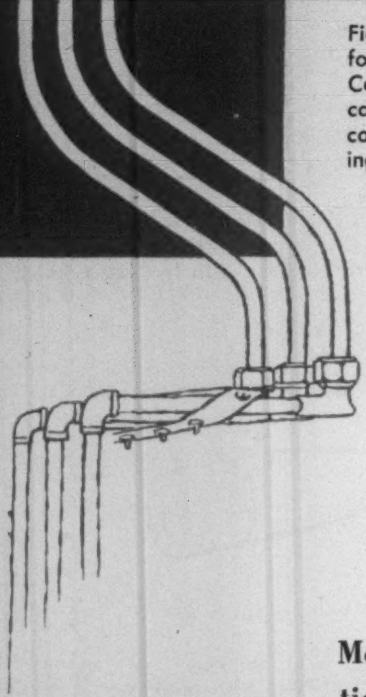


Fig. 1—The Georgetown Preparation Plant serves as a central preparation facility for strip mining and some underground mining operations of the Hanna Coal Co., Ohio operating division of Pittsburgh Consolidation Coal Co. With a capacity of 1500 tons of raw coal input per hour, Georgetown is the largest coal cleaning plant in the commercial bituminous industry, utilizing three cleaning circuits and five types of facilities for drying coal



AUTOMATIC LUBRICATION CUTS COSTS

Modern coal preparation plants create severe bearing conditions. Even under these difficulties, a centralized lubrication system, using one lubricant for almost all bearings, has increased bearing life, reduced maintenance costs and downtime, and eliminated the possibility of injuries from hand lubrication of moving equipment

FINEST LUBRICANTS in the world—finest machines ever developed, and yet, the oil can has been relied upon to apply one to the other. It is a time-worn axiom that perfect lubrication depends on a method that will assure the application of the right lubricant, in the right quantity, at the right time. If we accept this as the optimum formula in lubrication practice, it is apparent that the lubricant is but one element and a method or system of application must be employed to provide the other essential elements of control over quantity and time.

Obviously the human element, as represented by an oiler with his oil can or grease gun, cannot dispense the right quantity of lubricant at the right time to each and every bearing, even though using the best equipment. Merely to apply the right lubricant will not provide proper lubrication for today's automation.

Conventional lubricating methods, particularly those requiring hand work, normally require that the machine be shut down and involve considerable personal risk in covering various points of application. And, as a rule, the easy-to-reach bearings are flooded while the hard-to-reach are frequently neglected completely. This results in machine breakdowns, lost production and costly repairs. Conventional lubricating methods also waste grease. In hand gun application it is estimated that trial shots on the ground and dumping of contaminated lubricants waste all but perhaps 40 to 50 per cent of materials purchased.

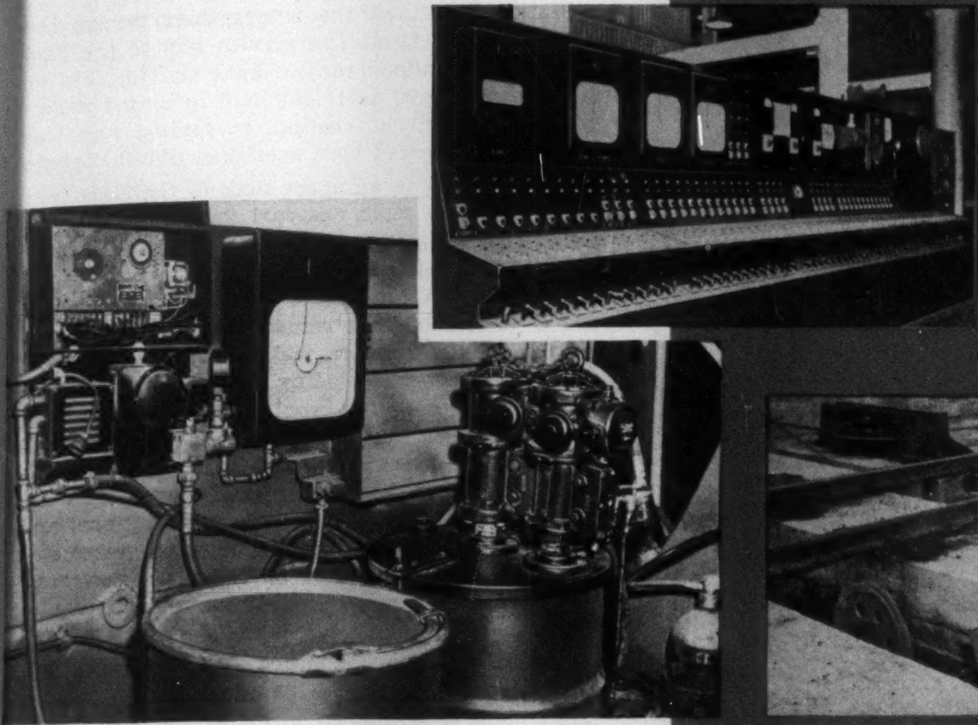


Fig. 2—One of three central lubricant pumping stations, with time clock control panel and 24 hour recorder automatically supplying lubricant to banks of processing machinery throughout the Hanna plant. Elements of the centralized lubrication system, are air motor and lubricant pump, adjustable time clock, and injectors located near the bearings. Predetermined frequency of the lubrication cycle is set on the clock. Cycle is automatically started by closing electrical circuit in relay switch on time clock panel. Solenoid air valve is automatically energized permitting air supply to pass to the air-motor of the pump. Lubricant, under pressure, is dispensed through the supply line, discharging injectors at line pressure. Injectors automatically recharge when pressure is relieved in supply line, completing the cycle. Entire system is controlled from master central plant control panel, top left half of which houses the pressure and cycle recorders

For these reasons, emphasis should be on correct lubricating procedure, on pumping directly from the original container to the point of use, and on the use of centralized automatic systems wherever possible. With centralized systems, all bearings automatically receive the right lubricant in the right quantity at the right time. Bearings are kept clean by exclusion of abrasive and corrosive substances and by injection of lubricants while shafts are in motion. This tends to distribute the lubricant evenly and maintain a seal at each end of the bearings.

▶ Designed-In Lubrication

The centralized system installed by Lincoln Engineering Co. in the Georgetown plant of the Hanna Coal Co., *Fig.* 1, solves this lubricant appli-

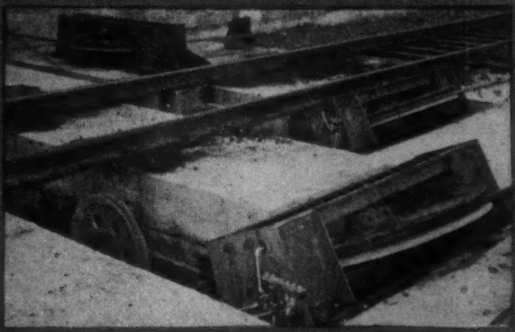


Fig. 3—Injectors supplying lubricant to the outside sheaves for railroad car hauling cable. The lubricant supply line from the pumping station to these injectors is over 400 feet in length

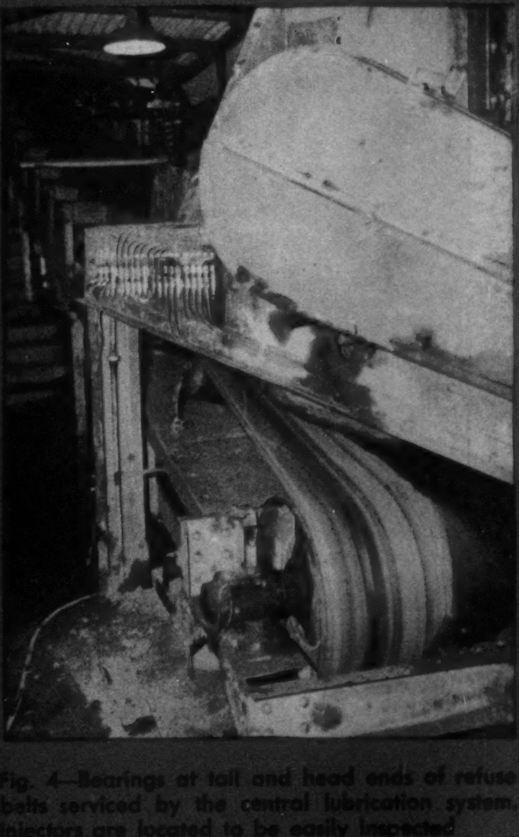


Fig. 4—Bearings at tail and head ends of refuse belts serviced by the central lubrication system. Injectors are located to be easily inspected

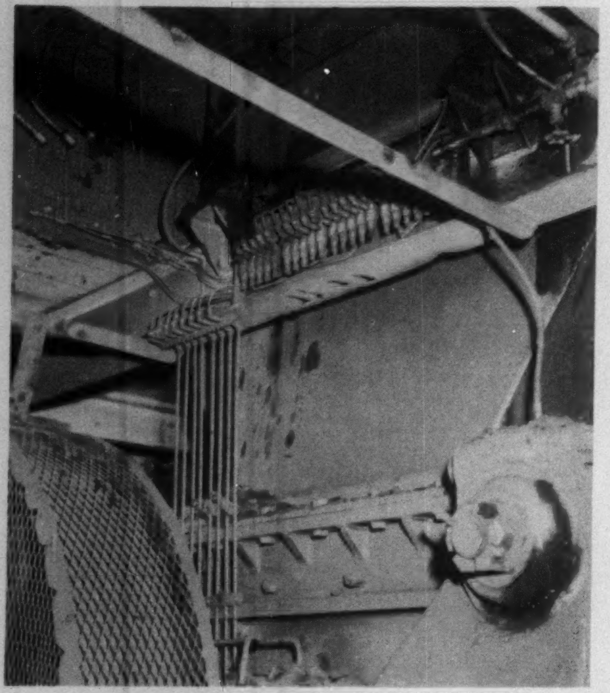


Fig. 5—Coal and stone crusher bearings are lubricated from grease supplied by the number two pumping station. Grease fittings on this equipment are not only difficult to reach but are often in locations dangerous to maintenance personnel

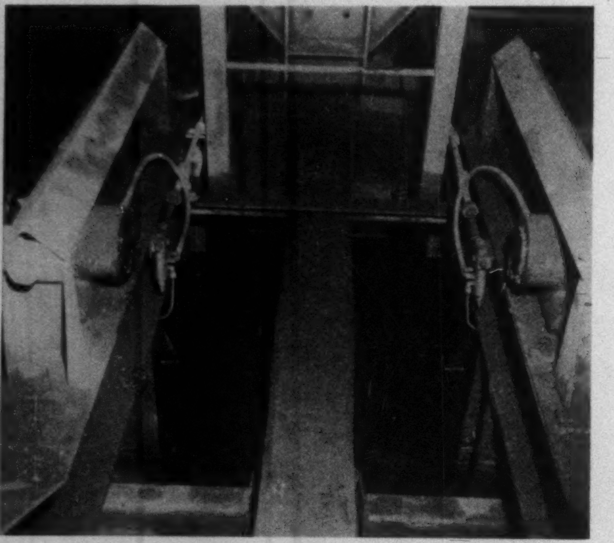


Fig. 6—Tail sprockets and bearings of settling tube conveyors are located 3 feet under this wash water. Injectors are above the surface with copper tubes feeding the underwater bearings

cation problem by serving over 1000 bearings. Automatic lubrication in the central plant is handled by three pumping stations dispensing grease, *Fig.* 2, and one station dispensing oil.

Station No. 1 at the rotary dump serves the dump and car haul. The service line to the haul and sheaves outside the car-haul building, *Fig.* 3, is more than 400 feet long and is buried underground. To prevent rusting, galvanized pipe was employed, protected by a special synthetic coating.

Station No. 2 in an upper floor of the plant near the head of the main raw-coal conveyor, serves injector circuits in the raw-coal and refuse-handling sections, *Fig.* 4. Maximum distance pumped by this station to the refuse bins is approximately 500 feet. Aside from refuse facilities, equipment served includes washers, picking tables and all subsidiary conveyors, including those feeding centrifugal driers, and two coal and stone crushers, *Fig.* 5. Underwater bearings on the sludge-tank conveyors also were included in the system, with injectors above the surface and copper lines extended down to the bearings to push out coal and water with lubricant, *Fig.* 6. The other grease station on the ground floor of the plant serves all drying and loading equipment as well as equipment in the table section.

For safety and continuity of service, each station is equipped with dual pumps so that if one fails the system can be switched immediately to the other. Also, complete failure of one pump does not interrupt lubrication as each station has sufficient capacity to take over the load of another.

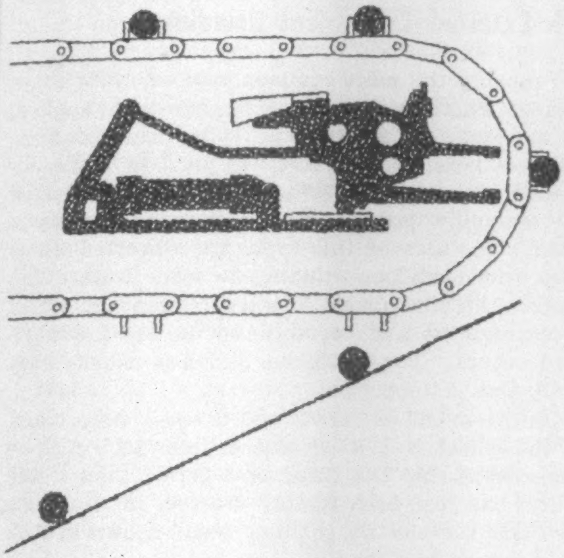
To insure that certain critical bearings get lubricated, each is fitted with two injectors so if one fails the other still can provide service. Also, all injectors have been placed in full view; failure may be revealed at a glance. Finally, bearings can be lubricated in an emergency with hand guns through the injectors which incorporate filler fittings.

The lubricating cycle in the preparation plant repeats every 15 minutes except for certain large slow-moving bearings, where a one-hour interval has been found satisfactory. Timers were set by studying each machine and type of service as well as the lubricant quantity injected per cycle. Lubricants consumed are reduced in spite of the increased frequency of application, largely through prevention of over-lubrication and waste in handling.

Installation of the Georgetown lubrication system required over 18,000 feet of supply lines and 14,000 feet of copper feed lines. The system required approximately two tons of grease to fill and was also designed so that it could be extended and additional outlets added to take care of future requirements. Naturally, this was accompanied by provision for sufficient capacity in pumping stations and lubrication lines.

Savings in a program such as that at Georgetown are derived from a reduction in the total cost of lubricating materials, a reduction in the cost of maintenance, and a reduction in the losses in production time. Maintenance savings alone have been estimated to be approximately $20,000 a year. If the centralized system had not been installed, satisfactory continuous operation would not have been possible, regardless of cost.

By ALBERT C. SANFORD
Engineering Department
Federal Products Corp.
Providence, R. I.



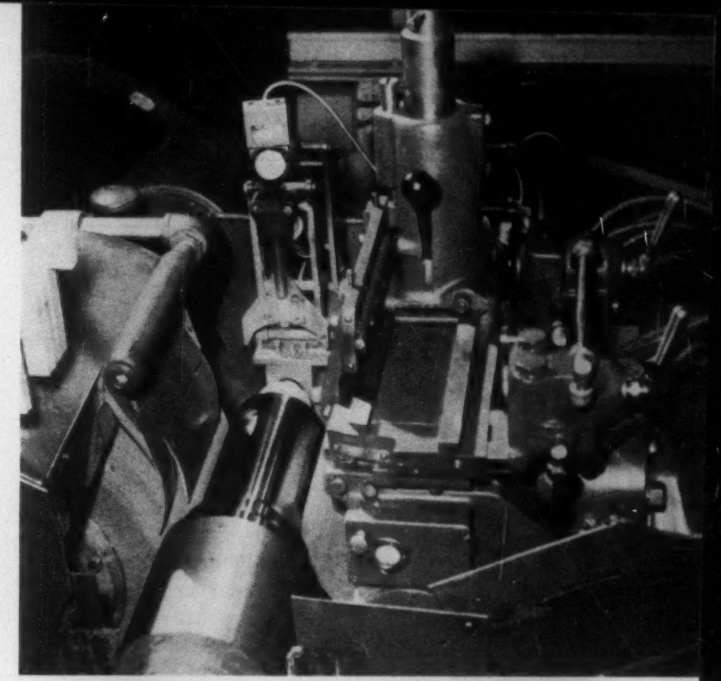


Fig. 9—Gage mounted on centerless grinder to control final grinding of journals in the production of railroad car axles

AUTOMATIC GAGING FOR CYCLIC PROCESSING

Part two of a series, this article discusses another facet of continuous machine control gaging—cyclic processing. The author discusses automation of in-feed grinding methods which offer problems common to cyclic operations

When grinding odd shaped parts on a centerless grinder it is not possible to throughfeed and plunge grinding must be used. With this method grinding wheels are retracted, work is loaded and then the wheels are advanced toward the work. Wheels generally advance toward a fixed machine stop and remain there for a given time cycle. It is anticipated that this will produce work of uniform size. However, due to variations such as wheel glazing or loading and possible temperature changes in the machine, desired size is not always achieved. As is the case in many instances, gage control of the machine direct from the critical area of the piece is necessary.

Modern production of railroad car axles, for example, is set up on an almost completely automatic basis. For final grinding of journals a gage, such as shown on *Fig. 9*, is mounted on the centerless grinder. This gage, details of which are shown in *Fig.* 10, is normally in a retracted or raised position. After an overhead crane has positioned the unground axle in the grinder the machine cycle starts. By means of an air cylinder the gage literally jumps onto the work and remains there during the grinding cycle. Because the side clearances of the work are restricted by the grinding and regulating wheels, the gage is arranged to take a chordal height measurement.

On large workpieces where the tolerance is in the order 0.0005-inch this method is satisfactory. However, where the tolerances are closer and where it is possible, it is much more desirable to obtain a full diameter measurement.

As the grinding cycle proceeds the gage dial continuously shows what is happening. In addition, the sensing head is tied in, through a suitable power unit, to three signal lights. These lights provide the operator with constant information as to what is occurring during the grinding cycle. First light indicates that the work is appreciably oversize, second light warns that the work is nearly to size, third light informs the operator that the work is to size and that the wheels of the machine should be backing away.

After the grinding cycle is completed and the wheels have backed away, the gage automatically retracts permitting the ground axle to be unloaded and the next machine cycle started.

External Cylindrical Grinding

Probably the most common type of cyclic processing, where machine control has been applied, is on external center type cylindrical grinding. In the normal operation, a part is manually loaded between centers and the cycle is started by manually pressing a button or operating a lever. In cases of this type, the wheel advances and grinds while continuing to move toward the work. After a given forward motion the wheel comes against a fixed stop and the spark-out period occurs. The spark-out period is usually controlled on a time basis.

Since control of work size is on a time basis, if the wheel is dull or glazed, less stock will be removed during the fixed time period than if the wheel has just been freshly dressed. In situations like this the electric grinding gage, shown in *Fig.*

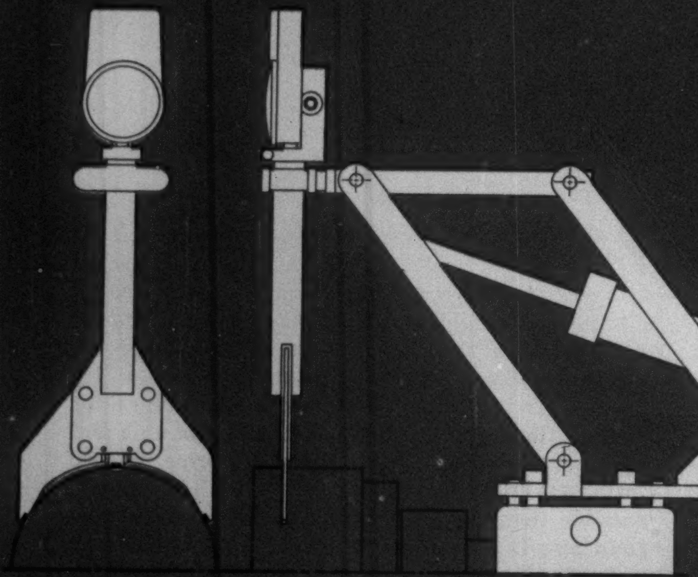


Fig. 10—Detailed drawing of the gage used to control final grinding as shown in *Fig.* 9

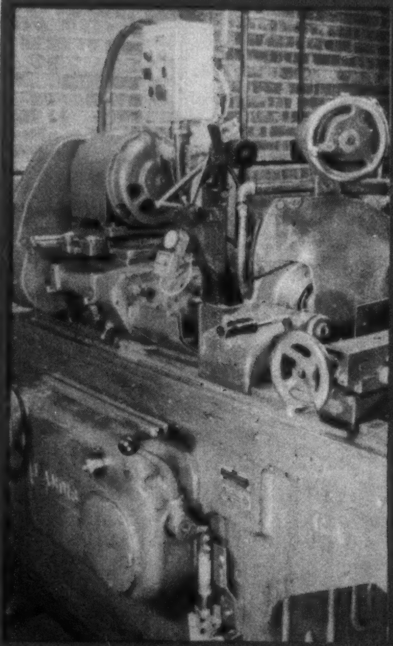


Fig. 11—Typical installation of an electric grinding gage mounted on a hydraulic grinder. When work is to size, gage de-energizes solenoid (which has been added to machine) and waits for new cycle

11, has proved to be very useful.

With this type gage the operator follows normal practice of loading and starting the machine cycle. He then manually positions the gage onto the work. The gage then takes over complete control of the machine operation and stock is removed until the gage is satisfied that the work is to size. At this instant the gage power unit commands the grinding wheel slide to retract. It is of particular importance to note that wheel back-up is controlled from work size and not by a fixed time cycle.

Where such gages are installed on newer machines they are generally arranged to provide what is called two-limit control. With this type of operation the grinding wheel moves toward the work in rapid traverse until it is within a few thousandths of the largest workpiece expected at this operation. The rate of feed then changes automatically (due to built in grinder controls) and the wheel progresses more slowly in what is known as rapid grinding.

When the workpiece measures approximately two to five thousandths larger than finished size, the gage signals the grinder and the rate of grinding feed diminishes to slow or dwell grind. The wheel is still advancing toward the work, but at a much slower rate. This is the equivalent of spark-out. As the work is continually reduced (though slowly) in size, the gage stands constant watch until it finds that the work is to size. When this occurs the gage again signals the grinder, the wheel backs up, the headstock spindle stops and the cycle is completed.

On older machines in the field, it is usually not practical to attempt double-limit gage control as this requires internal machine conversion. In such cases a single-limit electric grinding gage usually can be installed. With a single-limit grinding gage the operation is similar. Work is loaded between centers, the cycle started. The wheel advances in rapid traverse and changes to rapid grind. However, it continues its rapid grind until the wheel slide is physically stopped by a mechanical arrangement. Spark-out grind then begins.

The continuance of actual grinding at this point is dependent upon the amount of spring in the work and the machine. A single limit grinding gage is wired into the machine in such a manner that sometime during the spark-out period (after the wheel slide has reached the fixed stop) the gage arrives at finished size, causing the wheel to back up. The main advantage of the grinding gage in both of these applications is that it controls the machine from actual workpiece size and

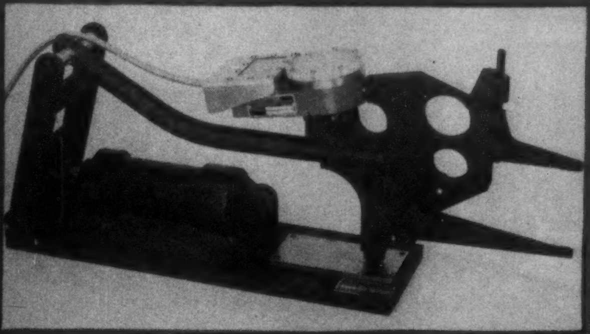


Fig. 12—left—Gage for automatic machines, shoe rides on skid plate carrying weight of gage until upper reference contact touches work. Shoe lifts off the skid plate and gage supports work

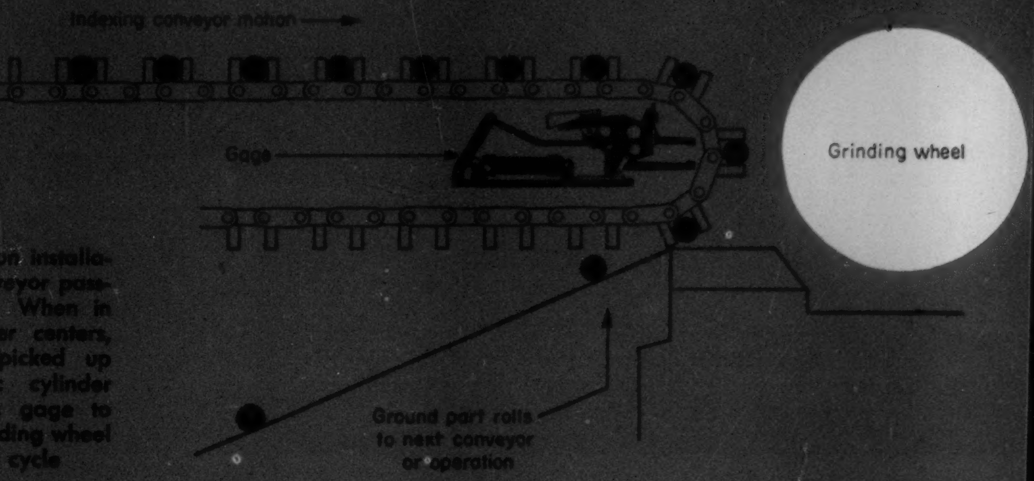


Fig. 13—right—Automation installation shows parts on conveyor passing over top of gage. When in position between grinder centers, part is automatically picked up from chain. Hydraulic cylinder built into gage causes gage to jump onto the work, grinding wheel then advances to begin cycle

centerless grinder. This gage, details of which are shown in *Fig.* 10, is normally in a retracted or raised position. After an overhead crane has positioned the unground axle in the grinder the machine cycle starts. By means of an air cylinder the gage literally jumps onto the work and remains there during the grinding cycle. Because the side clearances of the work are restricted by the grinding and regulating wheels, the gage is arranged to take a chordal height measurement.

On large workpieces where the tolerance is in the order 0.0005-inch this method is satisfactory. However, where the tolerances are closer and where it is possible, it is much more desirable to obtain a full diameter measurement.

As the grinding cycle proceeds the gage dial continuously shows what is happening. In addition, the sensing head is tied in, through a suitable power unit, to three signal lights. These lights provide the operator with constant information as to what is occurring during the grinding cycle. First light indicates that the work is appreciably oversize, second light warns that the work is nearly to size, third light informs the operator that the work is to size and that the wheels of the machine should be backing away.

After the grinding cycle is completed and the wheels have backed away, the gage automatically retracts permitting the ground axle to be unloaded and the next machine cycle started.

External Cylindrical Grinding

Probably the most common type of cyclic processing, where machine control has been applied, is on external center type cylindrical grinding. In the normal operation, a part is manually loaded between centers and the cycle is started by manually pressing a button or operating a lever. In cases of this type, the wheel advances and grinds while continuing to move toward the work. After a given forward motion the wheel comes against a fixed stop and the spark-out period occurs. The spark-out period is usually controlled on a time basis.

Since control of work size is on a time basis, if the wheel is dull or glazed, less stock will be removed during the fixed time period than if the wheel has just been freshly dressed. In situations like this the electric grinding gage, shown in *Fig.*

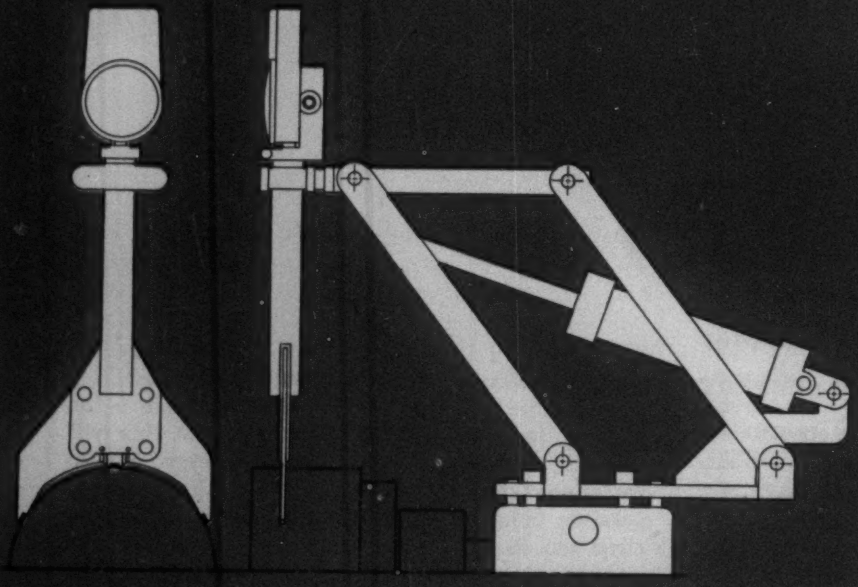


Fig. 10—Detailed drawing of the gage used to control final grinding as shown in *Fig.* 9

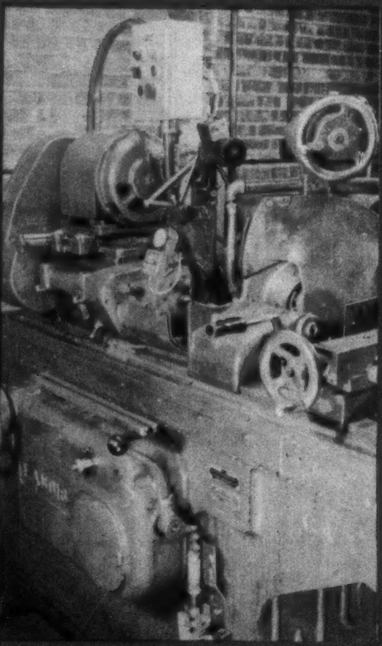


Fig. 11—Typical installation of an electric grinding gage mounted on a hydraulic grinder. When work is to size, gage de-energizes solenoid (which has been added to machine) and waits for new cycle

11, has proved to be very useful.

With this type gage the operator follows normal practice of loading and starting the machine cycle. He then manually positions the gage onto the work. The gage then takes over complete control of the machine operation and stock is removed until the gage is satisfied that the work is to size. At this instant the gage power unit commands the grinding wheel slide to retract. It is of particular importance to note that wheel back-up is controlled from work size and not by a fixed time cycle.

Where such gages are installed on newer machines they are generally arranged to provide what is called two-limit control. With this type of operation the grinding wheel moves toward the work in rapid traverse until it is within a few thousandths of the largest workpiece expected at this operation. The rate of feed then changes automatically (due to built in grinder controls) and the wheel progresses more slowly in what is known as rapid grinding.

When the workpiece measures approximately two to five thousandths larger than finished size, the gage signals the grinder and the rate of grinding feed diminishes to slow or dwell grind. The wheel is still advancing toward the work, but at a much slower rate. This is the equivalent of spark-out. As the work is continually reduced (though slowly) in size, the gage stands constant watch until it finds that the work is to size. When this occurs the gage again signals the grinder, the wheel backs up, the headstock spindle stops and the cycle is completed.

On older machines in the field, it is usually not practical to attempt double-limit gage control as this requires internal machine conversion. In such cases a single-limit electric grinding gage usually can be installed. With a single-limit grinding gage the operation is similar. Work is loaded between centers, the cycle started. The wheel advances in rapid traverse and changes to rapid grind. However, it continues its rapid grind until the wheel slide is physically stopped by a mechanical arrangement. Spark-out grind then begins.

The continuance of actual grinding at this point is dependent upon the amount of spring in the work and the machine. A single limit grinding gage is wired into the machine in such a manner that sometime during the spark-out period (after the wheel slide has reached the fixed stop) the gage arrives at finished size, causing the wheel to back up. The main advantage of the grinding gage in both of these applications is that it controls the machine from actual workpiece size and

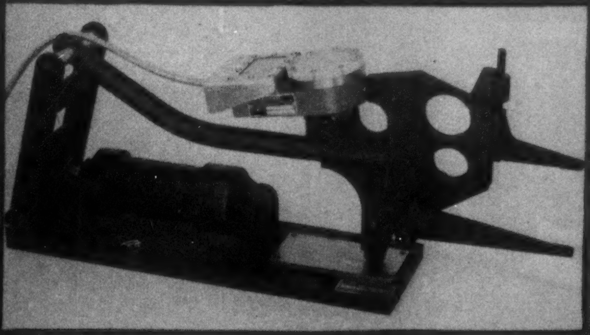


Fig. 12—left—Gage for automatic machines, shoe rides on skid plate carrying weight of gage until upper reference contact touches work. Shoe lifts off the skid plate and gage supports work

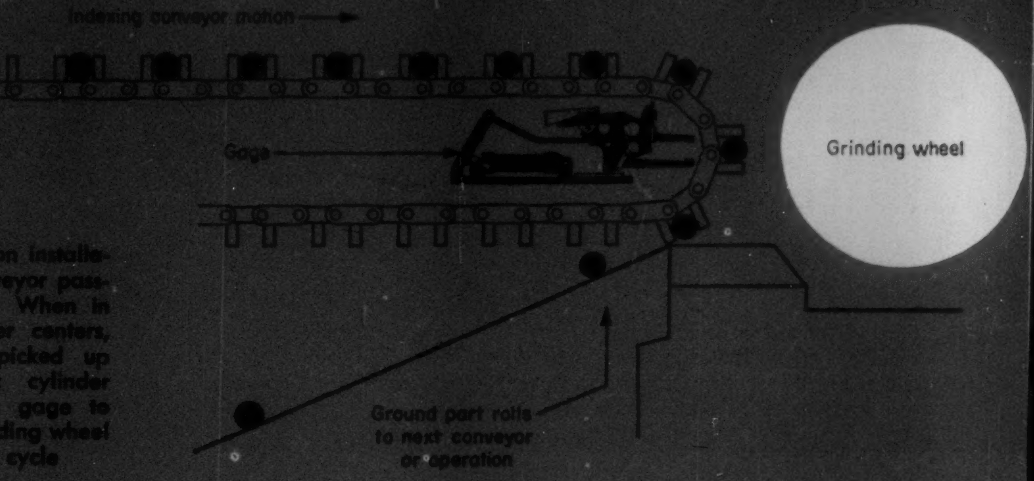


Fig. 13—right—Automation installation shows parts on conveyor passing over top of gage. When in position between grinder centers, part is automatically picked up from chain. Hydraulic cylinder built into gage causes gage to jump onto the work, grinding wheel then advances to begin cycle

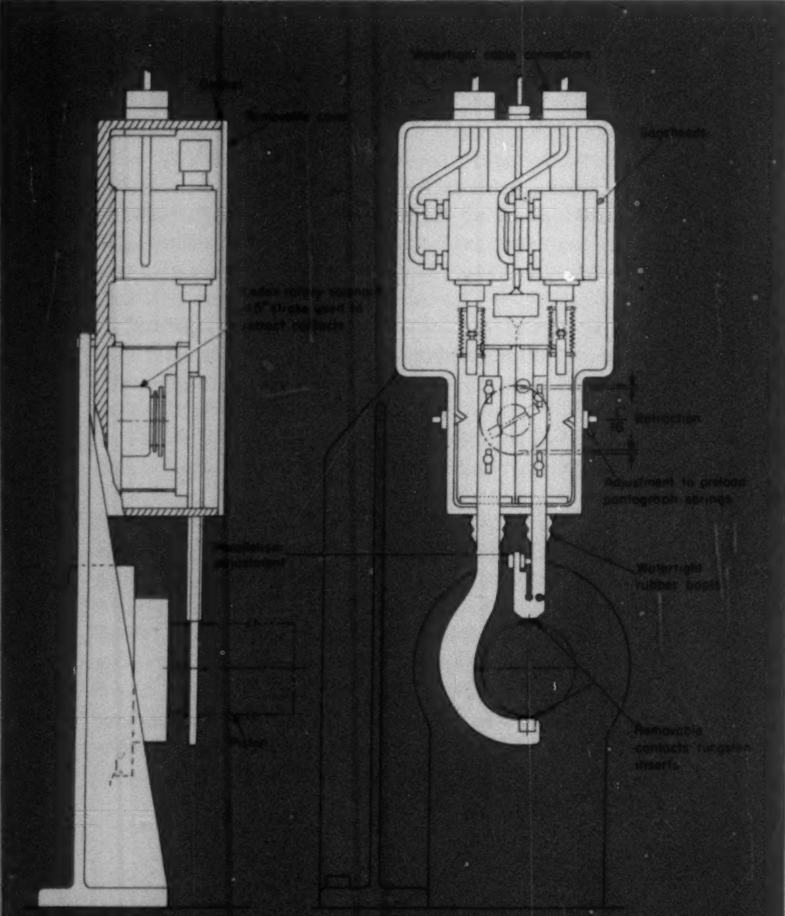

Watertight cable connectors
Gasket
Removable cover
Gageheads
Ledex rotary solenoid
15° stroke used to
retract contacts
1/16
Retraction
Adjustment to preload
pantograph springs
Oscillation
adjustment
Watertight
rubber boots
Removable
contacts tungsten
inserts
Piston

Fig. 14—Engineered for an automatic conveyor fed piston grinding line, electronic gage head is mounted from machine bed directly in front of the oscillating head stock

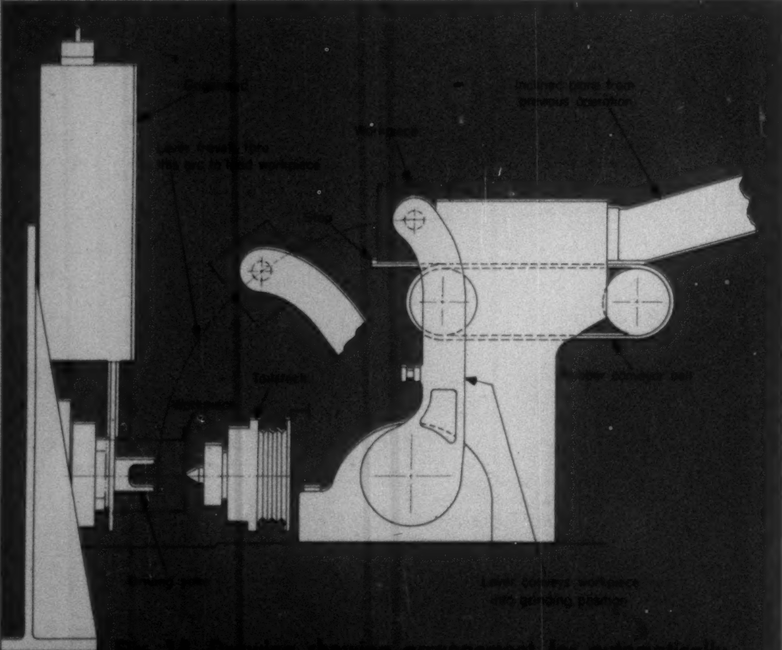

Gage head
Inclined chute from
previous operation
Workpiece
Lever travels thru
this arc to load workpiece
Stop
Tailstock
Rubber conveyor belt
Driving pin
Lever conveys workpiece
into gaging position

Fig. 15—Drawing showing arrangement for automatically [illegible] pistons. Pieces feed down chute and are advanced by continuously rotating rubber belt until loading position is reached

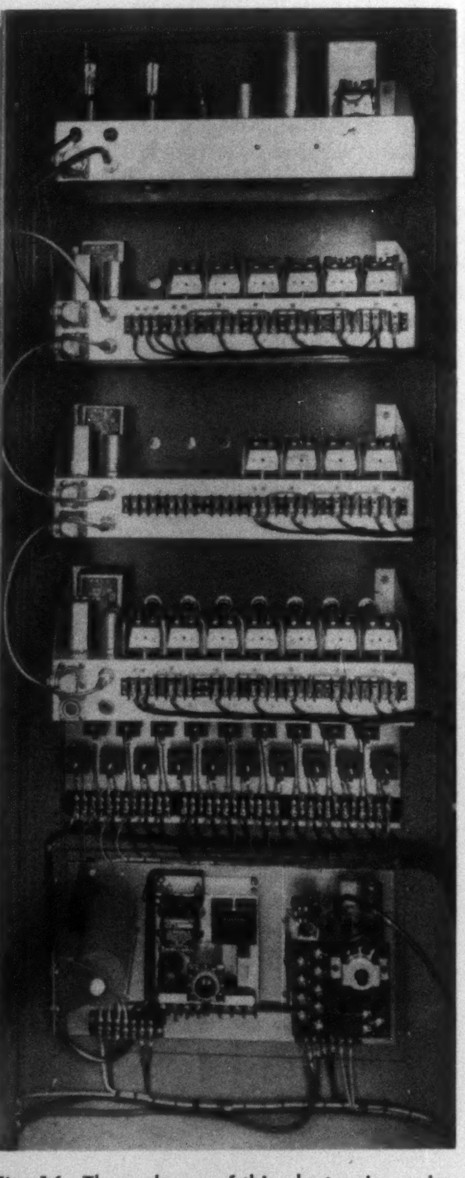


Fig. 16—Through use of this electronic equipment the gage shown in *Fig.* 14 observes only the major OD of the piston, ignoring completely minor diameters

is completely independent of machine temperature variations and wheel condition.

▶ Grinder Automation

Many of the more recently designed processes provide for conveyor feeding of workpieces from operation to operation. With automation there is no operator to manually load and unload workpieces. Parts are started at the beginning of the process and are carried through by conveyor with perhaps one operator attending a half dozen or more machines. In this type application it is necessary that the gage be as completely automatic as the machines and the process. The gage shown in *Fig.* 12 is intended for this type of work.

In one application this gage was positioned as shown in the sketch, *Fig.* 13. Parts move along on the conveyor and pass over the top of the gage. When the part is in position between centers of the grinder, the centers automatically pick the part up from the chain. Almost simultaneously, the hydraulic cylinder built into the gage causes the gage to jump onto the work and the grinding wheel advances to begin the cycle. The gage controls forward motion of the grinding wheel, changing its rate of grinding feed as necessary. When the workpiece is ground to size the gage again signals the machine, grinding wheel backs up, gage jumps back off the work into rest position, centers retract and the conveyor chain indexes, carrying the ground part underneath the gage to a succeeding operation.

While illustrated here for a grinding operation the principle of a gage literally jumping onto the work can also be used for other machining operations such as turning. However, in turning operations it is not always practical to have a gage ride the work while turning is taking place. With heavy cuts there may be a severe accumulation of chips. It is entirely conceivable that such chips could be heavy enough to actually cause damage to a gaging unit no matter how well constructed.

In modern conveyor fed turning operations, the jump-on gage can be positioned at the next chain

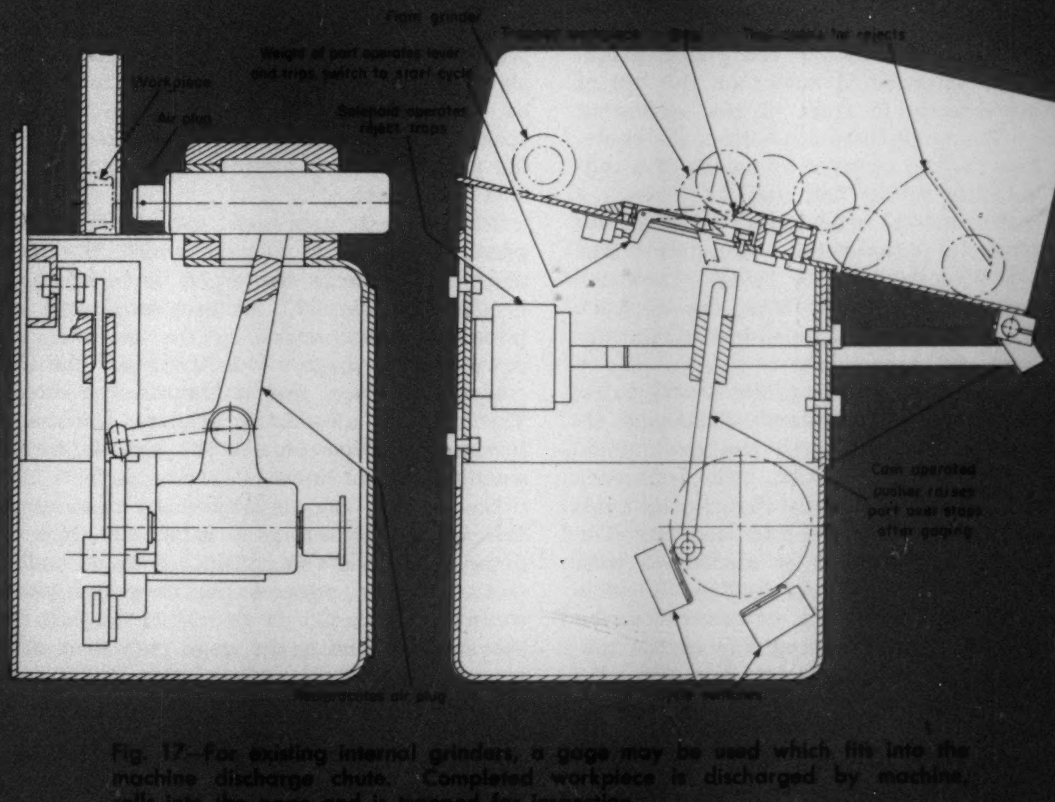

From grinder
Trapped workpiece
Stop
Trap opens for rejects
Weight of part operates lever and trips switch to start cycle
Workpiece
Air plug
Solenoid operated reject traps
Cam operated pusher raises part over stops after gaging
Reciprocates air plug
Cycle switches

Fig. 17—For existing internal grinders, a gage may be used which fits into the machine discharge chute. Completed workpiece is discharged by machine, rolls into the gage and is trapped for inspection.

station after the turning operation. The gage then jumps onto and measures the completed piece of work. Gage tolerances are set so that they are well within the actual workpiece limits. In this manner the gage will find size drift due to tool wear or other causes, and signal the machine for a correction before any defective pieces are made. In the event of tool breakage or other sudden changes, only one piece at the most will be defective. In this case the gage is arranged to shut the machine off and issue warning signals for the operator.

▶ Cam Shape Grinding

Manufacture of shapes other than cylindrical, an example of which might be a cam-ground piston, presents unusual problems in the field of machine control. These, however, have been solved by the use of electronic measuring heads in combination with a contacting device. In the usual cam shape grinding operation, the workpiece is held between centers or in a chuck and the entire headstock, footstock, and workpiece are oscillated toward and away from the grinding wheel during the grinding process. On a cam ground automotive piston the major OD of the cam shape (measured diametrically) may be as much as 0.015-inch larger than the minor diameter. The problem is one of measuring the major OD of this shape as it is being reduced in size, meanwhile ignoring the minor diameter of the piece, which is also being reduced in size.

Shown in *Fig.* 14 the gage is designed for a completely automatic conveyor fed piston grinding line. It is intended to mount on the bed of the machine directly in front of the oscillating head stock. The workpieces come down the chute, shown in *Fig.* 15, and advance by means of a continuously rotating rubber belt until they reach a stop. A power-driven arm inserts a plug into the wrist pin hole, picks up the piston and swings it through a 90-degree arc to bring it properly between the machine centers. Then the tailstock center advances moving the workpiece toward the headstock end of the machine.

Once the contacts of the gage are on the work, the machine grinding cycle starts. The gage itself does not oscillate with the headstock, footstock and workpiece combination. The workpiece actually slides back and forth slightly, approximately 0.008-inch between the gage contacts. The electronic equipment, which is associated with this gage, is of the type shown in *Fig.* 16. This electronic equipment provides a means for the gage to observe only the major OD of the piston, ignoring completely the minor diameter. By arranging the electronic circuit in this manner, it is not necessary to put high-speed timing or cycling switches on the machine which would need to be turned on to measure the major diameter and off to ignore the minor diameter. This is taken care of automatically in the rack and panel electronic equipment assembly.

As the major OD of the workpiece approaches finish size, the gage signals the machine to stop. In response to this signal the wheel retracts; the gage retracts its contacts through its hydraulic cylinder; the tailstock center retracts; a striper comes out of the headstock and pushes the piston off. The piston drops slightly, and rolls forward onto a succeeding conveyor. The entire cycle is then repeated.

▶ Internal Grinding

When considered for machine control, internal grinding presents certain specialized problems. Two of these problems are: physical space limitations and the short amount of time there is for gage measurement. Usually in internal grinding it is desirable to have the grinding wheel as large as possible, at least at the start of a particular setup. It is therefore not usually possible to have a gage in the workpiece at the same time that the grinding wheel is in the piece. It is entirely possible to insert an air gage plug into the work from the back end of the machine spindle. This air plug enters the work as the grinding wheel withdraws. As the cycle reverses the grinding wheel begins to enter the piece the air plug is withdrawn.

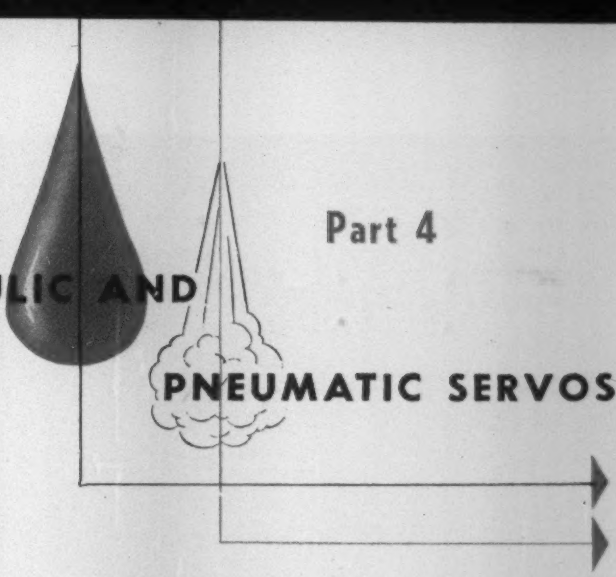
With modern high-speed wheel oscillation, the time available when the air plug is in the workpiece, is very short. An air gage and air-electric switch combination is required to have high response speed, with practically no mass allowed in the air switch in order to provide successful internal grinder control. Experimental work has shown that remarkably close work tolerances can be held with such a system. Due primarily to space limitations, it is not considered feasible at the present time to attempt such machine conversion in the field.

A practical approach for existing internal grinders is to use a gage which fits into the machine discharge chute. A gage of this type is shown in *Fig.* 17. As each workpiece is completed and discharged by the machine it rolls down into the gage and is trapped. The air plug enters the bore and measures the hole size. Through an air-electric system the gage determines whether or not the part is within the machine control limits.

Limits used are actually closer than workpiece tolerances. If the part is within these closer limits the process is considered to be under control, the gage releases the measured piece and waits for the next. In the event the part exceeds the machine limits, the gage trap door opens to accept that particular piece separating it from the good pieces. In addition the gage furnishes a signal which can provide visual or audible indications or can be used to shut down the process until the necessary corrections are made.

Final article of this three-part series will cover process control and will appear in the February issue of AUTOMATION.

By **R. HADEKEL**
Engineering Superintendent, Hydraulics
Sperry Gyroscope Co., Ltd.
Brentford, England



Part 4

HYDRAULIC AND PNEUMATIC SERVOS

FLOW CONTROL WITH VALVES AND PUMPS

Analysis of flow conditions and characteristics in theoretical and actual servo valve systems and in variable delivery pumps

Servo amplification based on control of pressure essentially depends on the deliberate provision of spring load on the motor element. Flow control does not necessarily differ from pressure control in the type of valve used, which is sometimes similar for the two cases, but chiefly in the fact that the motor is left unrestrained except by external load. In some cases of course the external load may contain substantial components equivalent to elastic restraint, as for instance aerodynamic loads on the control surfaces of an aeroplane, and in such cases it may be undesirable to use valves giving an effective "potentiometer" action except over a limited range. In any event, accurate control of flow by means of valves, just like accurate control by pressure, can be achieved only if external loads on the motor are low. Thus in borderline cases the difference between pressure and flow control may in effect be only one of degree. It is, however, convenient to classify as "flow-controlled" all those systems which do not include springs on the motor element introduced deliberately to cause the latter to move in proportion to applied pressure.

A four-way valve of the type shown in *Fig.* 37 (See Part 3—Dec. AUTOMATION) or any of its equivalents is used in conjunction with a double-acting cylinder (preferably with double-ended piston rod) or any form of rotary motor. The three-way type valve shown in *Fig.* 38 (See Part 3—Dec. AUTOMATION) or any equivalent seating valve may be used to control a "differential" cylinder, the annular side of which is connected to supply, as shown in *Fig.* 46. This system is perhaps not ideal for high power or high performance servos, but where applicable it has the advantage that the valve, *Fig.* 38, is appreciably easier to make than the one shown in *Fig.* 37, as it requires fewer close tolerances on axial dimensions, which are always a difficulty in slide valves for servo purposes; if seating valves are used, three-way types require fewer components than four-way valves. The valve, *Fig.* 38, can also be used in conjunction with two fixed resistances, as part of a Wheatstone bridge, as shown in *Fig.* 47. The equivalent circuit for a flapper valve was shown in *Fig.* 35 (See Part 3—Dec. AUTOMATION). Use of fixed resistances in potentiometer or Wheatstone bridge circuits allows

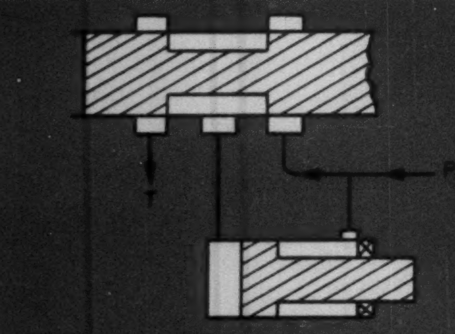


Fig. 46—Differential control using three-way valve

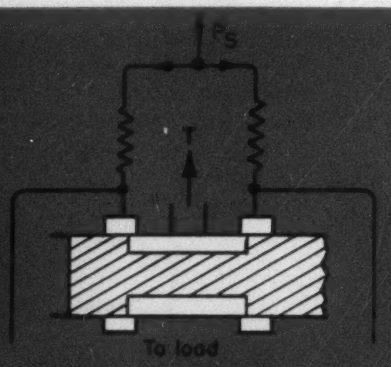


Fig. 47—Three-way slide valve used in conjunction with two fixed resistances as part of a Wheatstone bridge

still simpler control valves, viz. two-way types, i.e. single variable resistances. Two possible circuits are shown in *Fig.* 48, in which the variable resistance symbol denotes any suitable two-way valve, slide or seating.

It should be noted that if the valve has negative lap, or if the circuits of *Figs.* 47 or 48 are used, when the cylinder is held fixed it will develop a load which for small travels is proportional to the valve displacement. If the servo consists only of the single valve and cylinder (plus of course the differential and feedback path) as in *Fig.* 1 (See Part 1—Oct. AUTOMATION), the valve displacement is the error signal; the output load developed per unit error when the output is stationary is termed the "static output stiffness" of the servo, which can therefore be easily calculated in the cases in question. With a zero lap valve the stiffness is infinite, since under static conditions the cylinder will exert full load for any non-zero valve displacement, however small. This is no longer true if there is a leakage path from one side of the motor element to the other, as is inevitable in the case of rotary motors—in the case of cylinders a shunt resistance across the cylinder is sometimes deliberately added to increase stability, as will be shown later; in such cases the output stiffness is finite even with zero lap. The output stiffness is of importance in that it measures errors induced by external disturbances, e.g. wind loads on a gun or a radar aerial. It can be shown that the output stiffness is always infinite if the servo is of the "second order" (or zero velocity error) type.

▶ Valve Flow Characteristics

With a four-way valve controlling a double-acting cylinder or rotary motor, control is obtained by throttling the flow to the load (i.e. motor element) and also the return flow from the load. With a double-ended cylinder the forward and return flows are equal, except for compressibility effects which may be neglected for present purposes. With a rotary motor the situation will usually be different, as the motor casing is usually vented to tank through a leakage return line, in order to avoid exposing the shaft seal to high pressures. Most seals suitable for high speed rotary shafts cannot withstand pressures much higher than 100 psi. Forward flow will then exceed return flow by an amount equal to the flow in the leakage return line, which may be kept quite low by judicious design. It seems reasonable to assume that such small differences will not have any appreciable effect on the overall characteristics of the servo. It will therefore be sufficient to consider conditions in which forward and return flows are equal. In the case of four-way valves it will be further assumed that the valve is symmetrical, i.e. that the orifices on the forward and return side are equal for any valve travel (for most designs of valve this is the same as saying that the amount of lap is equal on either side of the valve land when the valve is central).

Fluid is throttled at an orifice by converting its pressure energy into kinetic energy. Under conditions prevailing in servo valves, the kinetic energy of the fluid before throttling is negigible as compared with that in the orifice, the size of which is much smaller than that of the general passages in the valves, or of the pipes. Furthermore, no appreciable portion of the kinetic energy is reconverted to pressure energy. Under such conditions the flow through an orifice is given by

$$Q = CA\sqrt{2p/\rho} \quad \ldots\ldots\ldots\ldots (6)$$

where A is the orifice area, ρ the density of the fluid, p the pressure loss in the orifice, and C the orifice coefficient, which may vary between about 0.6 and 0.8, or somewhat more. If the ports at which throttling occurs are in the form of full grooves in the valve sleeve (in the case of a slide valve), the value of C is likely to be about 0.8.

In practice, conditions are somewhat more complicated. At very small valve openings, viscous forces play an appreciable part, and the flow may be considerably less than that given by Equation 6;

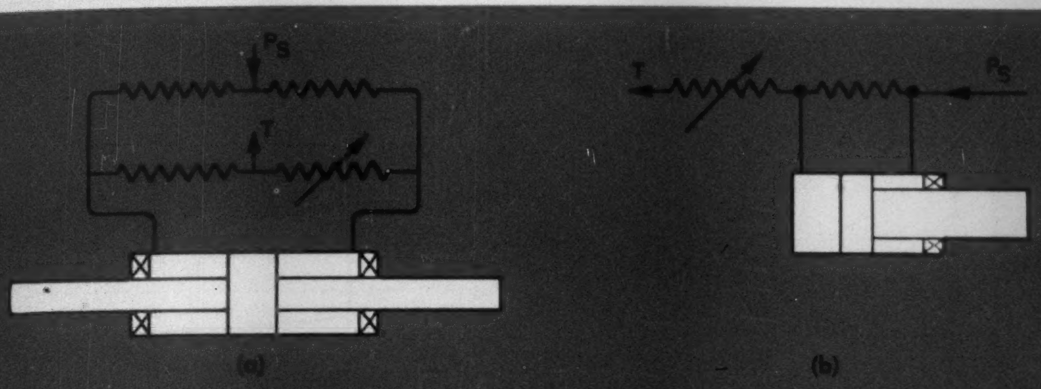


Fig. 48—Control circuits using one variable resistance double-acting is shown at a and differential type at b

even at appreciable openings C may still vary slightly with valve travel. Furthermore, recent research (not yet published) seems to indicate that at a fixed valve opening the flow may vary slightly with time, for a short transient period after the valve has been rapidly moved—if the phenomenon were linear it could be expressed by a transfer function different from a constant. All these effects, however, are as yet imperfectly known, possibly too complicated to handle analytically, and very probably of no great influence on the overall characteristics of the servo. Thus for lack of anything more accurate, but still with sufficient confidence, Equation 6 may be taken as applicable, with the coefficient C regarded as independent both of time and of valve opening.

Consider an orthodox four-way slide valve with zero lap, Q will then be the flow to the load (motor). With the conditions of symmetry stated above, the total pressure drop in the valve, i.e. the sum of the drops in the forward and return orifices, will be $P = 2p$, where p is the drop in each orifice. Then with $\rho = 0.85$ grams per cubic centimeter, $C = 0.8$, and with Q in cubic inches per second, P in psi and A in sq in. the relation between flow and *total* pressure loss is

$$Q = 89\,A\,\sqrt{P} \qquad (7)$$

If the ports are in the shape of full grooves, and if D is the valve diameter in inches and x the valve travel in *thousandths of an inch*, Equation 7 can be written

$$Q = 0.282\,D\,x\,\sqrt{P} \qquad (8)$$

Fig. 49 shows the above equation in the form of a nomogram, for valves of 0.25-inch and 0.5-inch diameter.

Equations 7 and 8 and *Fig.* 49, also apply to valves with non-zero lap for valve travels greater than the amount of lap, if x is the algebraic difference between valve travel and lap, underlap being given a negative sign.

Any valve of the type analyzed, or more broadly any valve to which Equation 7 applies and in which the area increases linearly with travel, is linear in the sense that the flow is proportional to travel for a fixed pressure drop only. Further analysis is required to investigate the general case in which pressure drop cannot be regarded as constant.

Flow conditions in valves have been investigated in some detail by Blackburn,[12] who points out certain analogies between hydraulic and electronic valves, which will not be pursued here. In other respects the present discussion is based on Blackburn's treatment, with certain modifications and additions. *Fig.* 50 shows the flow conditions in a four-way valve, which for the sake of generality is shown as having negative lap. Flow to the "load" (which is generally some form of motor, but which may include a shunt resistance as shown dotted) is denoted by Q_L; P_L is the pressure across the load, and P_s the supply pressure. The valve is assumed to be linear in the sense that the area increases linearly with the valve travel x, which is measured from the central position. Equation 6 may then be written

$$q = B(u \pm x)\,\sqrt{p}$$

where p is the pressure drop in any orifice, q the flow through that orifice, and u the underlap, provided $u - x$ is positive. With the units, constants, and assumptions stated above, and for ports in the shape of full grooves, the constant B works out at 0.4 D, where D is the valve diameter in inches (not 0.282 D as in Equation 8, because p is now the pressure drop in one orifice, not two). The pressure drop in any orifice will be given by

$$p = \frac{P_s - P_L}{2}$$

By applying the flow equations to the four orifices shown in *Fig.* 50, and allowing for symmetry conditions, the flow Q_L to the load is worked out as a function of the valve opening x and load pressure P_L.

For the case of the "ideal valve", i.e. valve with zero lap, let x_m be the maximum travel, let

---

[12] References are tabulated at end of article.

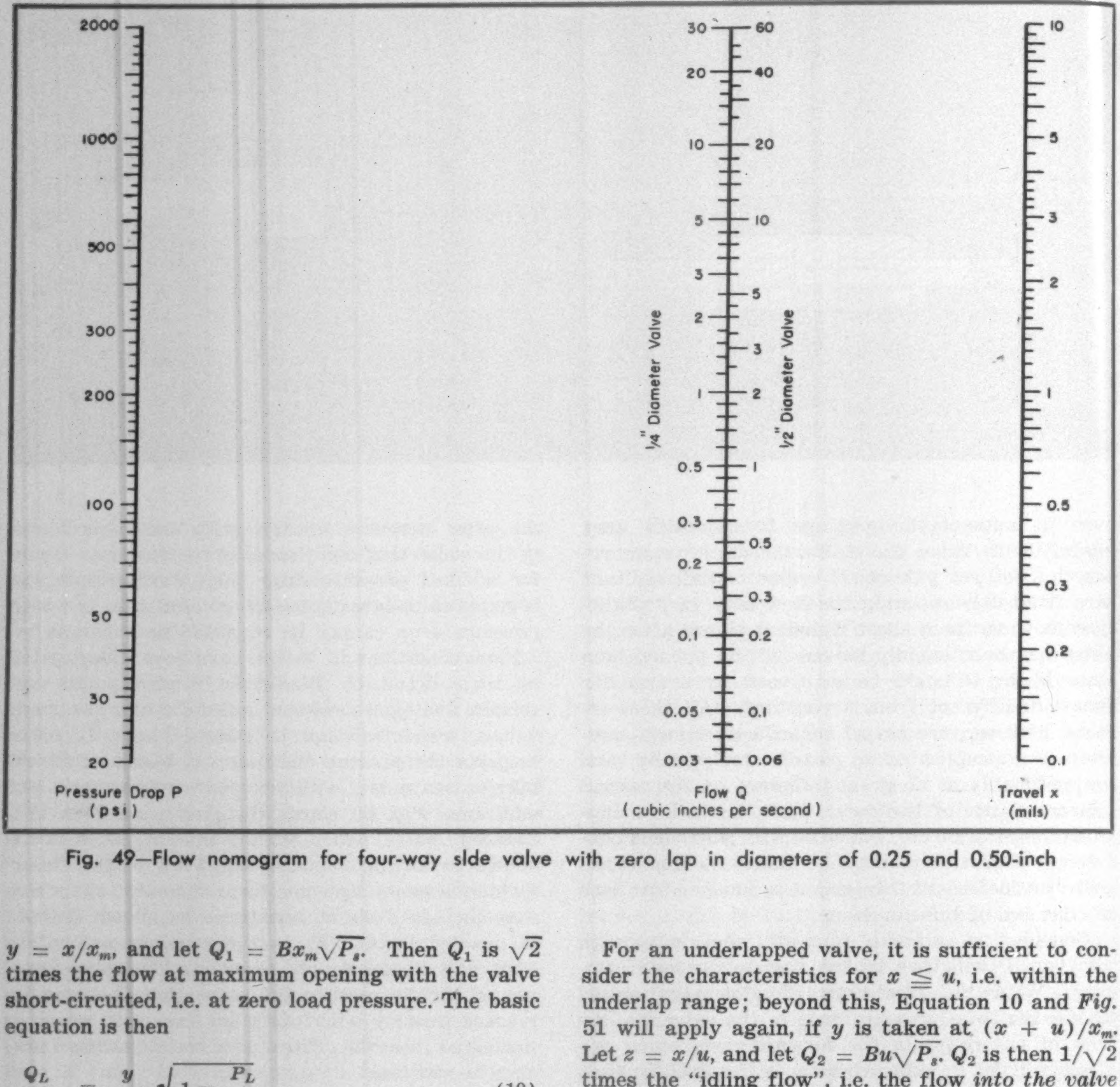


Fig. 49—Flow nomogram for four-way slide valve with zero lap in diameters of 0.25 and 0.50-inch

$y = x/x_m$, and let $Q_1 = Bx_m\sqrt{P_s}$. Then Q_1 is $\sqrt{2}$ times the flow at maximum opening with the valve short-circuited, i.e. at zero load pressure. The basic equation is then

$$\frac{Q_L}{Q_1} = \frac{y}{\sqrt{2}}\sqrt{1 - \frac{P_L}{P_s}} \qquad \text{(10)}$$

the resulting characteristic being shown in *Fig.* 51.

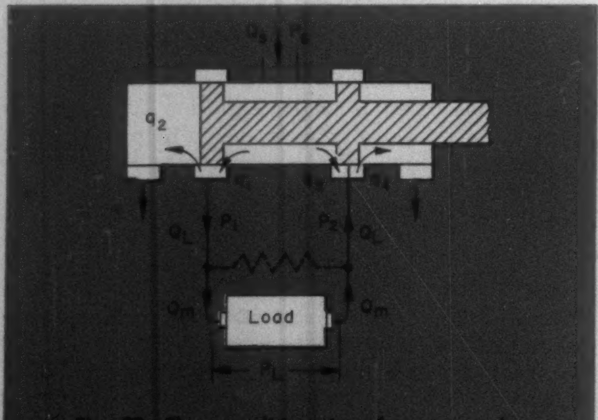


Fig. 50—Flow conditions in a four-way valve, shown having negative lap

For an underlapped valve, it is sufficient to consider the characteristics for $x \leqq u$, i.e. within the underlap range; beyond this, Equation 10 and *Fig.* 51 will apply again, if y is taken at $(x + u)/x_m$. Let $z = x/u$, and let $Q_2 = Bu\sqrt{P_s}$. Q_2 is then $1/\sqrt{2}$ times the "idling flow", i.e. the flow *into the valve* (or out of it) when the latter is central. The basic equation then works out at

$$\left(\frac{Q_L}{Q_2}\right)^2 = 1 + z^2 - 2z\frac{P_L}{P_s} - (1 - z^2)\sqrt{1 - \left(\frac{P_L}{P_s}\right)^2} \qquad \text{(11)}$$

the resulting characteristic being shown in *Fig.* 52. Note the close approximation to linearity over much of the underlap range.

Another case of interest is that of the underlapped valve with a constant delivery pump, when the underlap is so large as to pass the full output of the pump at a pressure substantially below the relief valve setting; significance of this case will be discussed presently. The supply flow Q_s is now constant and the supply pressure variable. Let $P_1 = Q_s^2/B^2u^2$; P_1 is then the "idling pressure", i.e. the supply pressure when the valve is held central—the load must then be zero. The equation for this case is

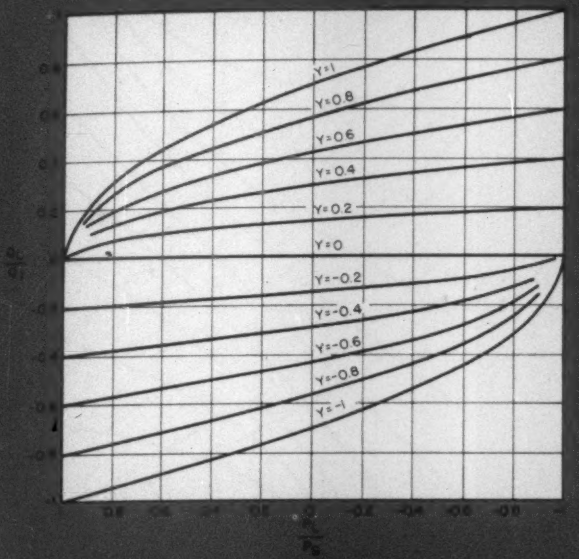


Fig. 51—Flow characteristics for ideal four-way valve

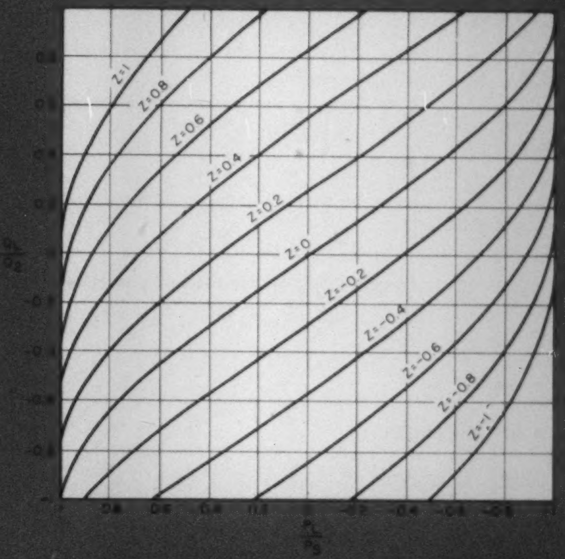


Fig. 52—Flow characteristics for underlapped four-way valve at constant supply pressure

$$\left(\frac{P_L}{P_1}\right)(1-z^2)^2 = z\left(\frac{Q_L}{Q_s}\right)^2 -$$

$$(1+z^2)\left(\frac{Q_L}{Q_s}\right) + z \quad \text{(12)}$$

the resulting characteristic being shown in *Fig.* 53.

Blackburn has also worked out the case of the flapper valve illustrated in *Fig.* 35—the results would apply equally well to the circuit of *Fig.* 47. Optimum conditions are obtained when the fixed resistances (assumed to be of the orifice type) are equal to the variable resistances at the flapper when the valve is central. In this case for a fixed supply pressure the equations are

$$\frac{p2}{P_s}\alpha^2 = \alpha + (\alpha - 2)\left(\frac{Q_L}{Q_1}\right)^2 -$$

$$2(1-z)\left(\frac{Q_L}{Q_1}\right)\sqrt{\alpha - \left(\frac{Q_L}{Q_1}\right)^2}$$

$$\frac{p_4}{P_s}\beta^2 = \beta + (\beta - 2)\left(\frac{Q_L}{Q_1}\right)^2 +$$

$$2(1+z)\left(\frac{Q_L}{Q_1}\right)\sqrt{\beta - \left(\frac{Q_L}{Q_1}\right)^2} \quad \text{(13)}$$

with $P_L = p_2 - p_4$; $\alpha = z^2 + 2 - 2z$; $\beta = z^2 + 2 + 2z$. The resulting characteristic is plotted in *Fig.* 54.

When the supply flow is constant at Q_s, the equations become

$$S^2 z + S(1+z^2) + z - (P_L/P_1)(1-z^2)^2 = 0 \quad \text{(14)}$$

where $S = P_L/P_1 + 2Q_L/Q_s$.

Resulting characteristic is plotted in *Fig.* 55.

As already mentioned, if the load is a rotary motor, there will be appreciable leakage from one side to the other, while if the motor is of the cylinder type leakage is sometimes introduced deliberately in order to improve stability. Both cases can be represented by a resistance shunted across the motor, as shown dotted in *Fig.* 50. In the case of a rotary motor, the effective shunt can be represented by a resistance of the viscous type, while in the other case the resistance may be of the viscous (linear) or orifice (square law) type. Let B_r be the conductance coefficient of the shunt. Then in either case the flow to the motor is given by

$$Q_m = Q_L - B_r P_L^n \quad \text{(15)}$$

where the exponent "n" is unity for a viscous resistance, and 1/2 for an orifice resistance.

Two parameters are of special importance for subsequent stability calculations. They are the "valve gain constant" and the "pressure factor"

$$G = \frac{\partial Q_m}{\partial x} \text{ where } P_L \text{ is a constant}$$

$$R = \frac{\partial Q_m}{\partial P_L} \text{ where } x \text{ is a constant}$$

In the case without shunt $Q_m = Q_L$. The cases analyzed later on are those of an ideal valve with and without shunt, and an underlapped valve with constant pressure and without shunt. Partial derivatives may be obtained from Equations 10, 11, and 15, and are as follows:

Ideal valve without shunt:

$$G_1 = B\sqrt{P_s/2}\,\sqrt{1-(P_L/P_s)} \qquad (16)$$

$$R_1 = \frac{Bx}{2\sqrt{2P_s\left(1-\frac{P_L}{P_s}\right)}} \qquad (17)$$

The sign of x must always be taken positive.

Ideal valve with shunt: $G_2 = G_1$.

With viscous shunt

$$R_{2v} = R_1 + B_r \qquad (18)$$

With orifice shunt

$$R_{2o} = R_1 + B_r/2\sqrt{P_L} \qquad (19)$$

Underlapped valve, for small valves of P_L:

$$G_3 = B\sqrt{2P_s} \qquad (20)$$

$$R_3 = Bu/\sqrt{2P_s} \qquad (21)$$

Note that for the ideal valve without shunt, R is zero in the central position, which, as will be shown, is unfavorable to stability. In other cases R is always negative, which is favorable. For the ideal valve with orifice shunt, R is infinite at zero load.

For the case discussed earlier, i.e. a servo consisting just of a valve, motor, direct feedback link and differential, the output stiffness is given by $\partial F/\partial x = A\partial P_L/\partial x$, where F is the cylinder load and A its area, the partial derivatives being taken with Q_m constant. Now

$$\frac{\partial P_L}{\partial x} = \frac{-\frac{\partial Q_m}{\partial x}}{\frac{\partial Q_m}{\partial P_L}} = \frac{G}{R}$$

and the output stiffness can thus be calculated directly from the parameters G and R. To get the *static* stiffness, i.e. the stiffness with the motor stationary, Q_m is put to zero, and either P_L or x is eliminated from the characteristic equation, e.g. Equation 10 or 11 etc. Thus for the underlapped valve with constant supply pressure, the static stiffness factor is

$$\frac{\partial P_L}{\partial x}\Big/_{Q_m=0} = \frac{2P_s}{u}$$

when the valve is in the central position.

Underlap and Power Consumption

With an underlapped valve there is some flow into the valve, and back to tank, even when the flow to the load is zero, i.e. even when no work is being done. This does not always imply additional dissipation of power; for instance, if the supply is from a constant delivery pump fitted with a relief valve, the power consumption is always equal to the peak pump power, and cannot be increased; in this case there is no objection to providing quite appreciable amounts of underlap. If on the other hand a cut-out system is used, or if the pump is of the automatic variable delivery type, underlap causes additional dissipation of power, and must usually be limited to quite low values on that score.

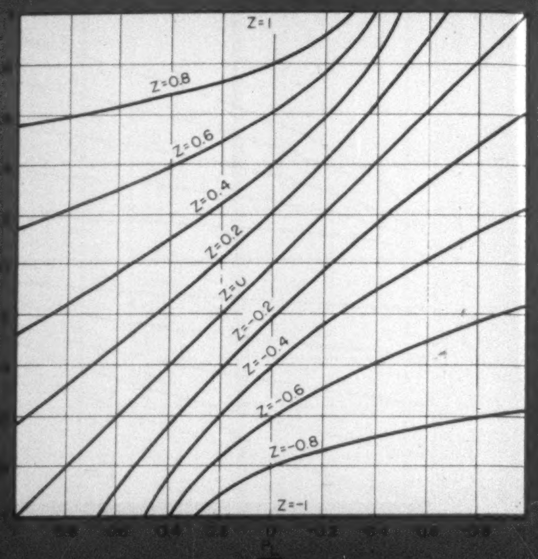


Fig. 53—Flow characteristics for underlapped four-way valve at constant supply flow

The situation is different, however, if the pump is again of the constant delivery type used in conjunction with a relief valve, without any other power economy devices, and the underlap is made so large as to cause the supply pressure to drop to a value very much lower than the relief valve setting, when the control valve is in the central position. This is the case described by Equations 12 and 14, and *Figs*. 53 and 55. The pump is then substantially unloaded when the valve is central, and the arrangement is equivalent to what is known in ordinary hydraulic machinery as an "open center system". For servo purposes an open center system has its limitations; the control characteristics are not very favorable, as may be seen from the shape of the curves of *Figs*. 53 and 55 (which for this purpose should really be extended beyond $P_L/P_1 = 1$), and the output stiffness is low, which may lead to difficulties with stability. Furthermore, the unloading effect is lost if the servo must sustain fixed loads of high magnitude (due for instance to elastic effects or their equivalent) for long periods of time. It is, however, possible to deal with this case by providing some mechanical or hydraulic non-reversing device, together with

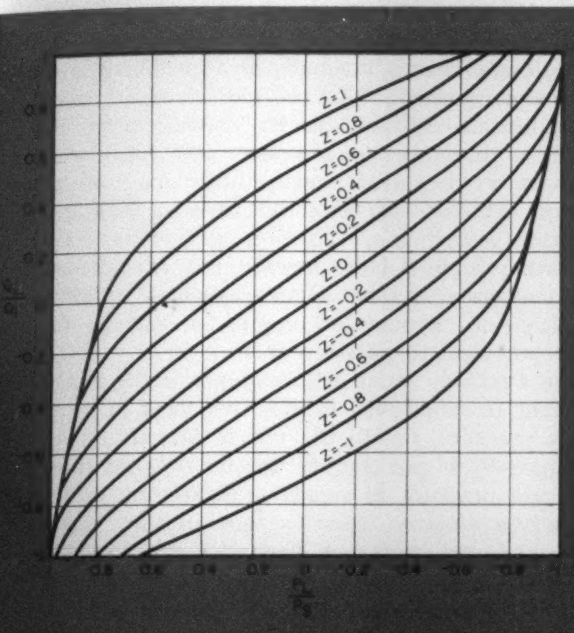


Fig. 54—Flow characteristics for circuits of Figs. 35 and 47 at constant supply pressure

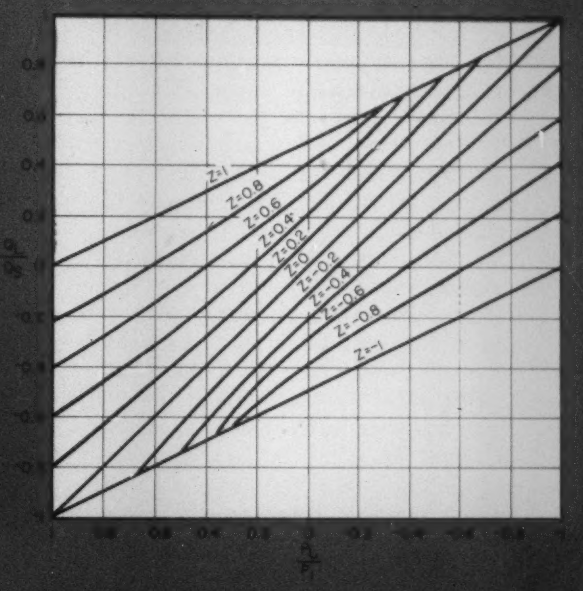


Fig. 55—Flow characteristics for circuits of Figs. 35 and 47 at constant supply flow

spring centering on the valve. In favorable cases, however, an open center system may form a very good solution—certainly the simplest one—to the problem of reducing power dissipation. Obviously there is room for compromising between the requirements of a low idling pressure and good control characteristics, by adjusting the amount of underlap.

A point worth noting is that without underlap, or under conditions when the valve travel exceeds the amount of underlap, for a fixed supply pressure the power delivered to the load is a maximum when $P_L = 2/3\ P_s$. This, however, is not necessarily the best criterion for settling the size of cylinder or other form of motor, which of course determines the peak value of P_L for a given peak load; power dissipation will be reduced by making P_L still larger, while non-linearity effects will be reduced by making P_L smaller. In actual servos values of P_L ranging from 0.59_s to $0.8P_s$ are not uncommon, at peak loads.

▶ Design of Pump-Controlled Servos

In valve-controlled servos the fluid is throttled both at the inlet to the motor and at the outlet from it, and hence both lines to the motor are normally under substantial pressure. With control by variable delivery pump, however, there is no inherent tendency for the return line to be under pressure; now low pressure in one of the lines between pump and motor would cause excessive elasticity, owing to the seemingly inevitable inclusion of suspended air in the oil. It is therefore usual to provide a "base pressurizing" or "supercharging" system to ensure that both lines are always under appreciable pressure; the minimum pressure is seldom made less than 100 psi, and sometimes is as high as 500 psi.

Before describing supercharging methods another point must be mentioned—the loads required to actuate the pump delivery control lever (or equivalent member) are usually too high for direct operation, and it is common practice to provide some force amplification; this usually takes the form of a simple valve-controlled servo, which for obvious reasons must require a separate source of supply.

The orthodox method of solving both the above problems is shown in *Fig.* 56. There is a small auxiliary pump which provides the supply for the preamplifier servo, and at the same time provides a base pressure to the main system by discharging into both lines through non-return valves. This method of supercharging also avoids the difficulties which would otherwise be created by the fact that leakage losses in the main pump would have to be made up from the tank through non-return valves operating at subatmospheric pressure, which tend to be delicate.

In view of its low power, the auxiliary pump can be of fixed displacement discharging into a relief valve, as shown in *Fig.* 56; the relief valve setting then determining the base pressure. Auxiliary pumps of the automatic variable delivery type are also used.

Flow from Variable Delivery Pumps

A widely used type of variable delivery pump is shown in diagrammatic form, *Fig.* 57. The cylinder block is driven, and the piston heads bear on an eccentric track, being kept against it during the suction stroke by centrifugal force, and sometimes also by springs. The cylinder block rotates on a fixed distributor shaft (also called "valve shaft", "pintle", etc.) which is formed with two grooves registering with ports at the bottom of the cylinders, and communicating with the two main connections through drilled passages in the shaft, the disposition being such that one groove communicates with the cylinders in their delivery stroke, and the other in their suction stroke. The stroke is equal to twice the eccentricity of the track, and the latter can be varied by sliding the track in fixed guides in the pump body, thus altering the delivery, and reversing it when passing through the concentric position.

In practice there are some constructional refinements. In particular the track may be lined with a roller race to prevent high rubbing speeds, or the piston heads may be fitted with slippers conforming to the track to ensure lubrication, or both. There are also various other types of variable delivery pumps equally suitable for servo purposes, the characteristics of which are, however, quite similar to those of the type described. The design of these or any other pumps is a somewhat specialized subject, and is therefore outside the scope of the present text.

The pump casing is usually at atmospheric pressure, since putting it to the base pressure would make life too difficult for the driving shaft seal. There is therefore some leakage over the mating surfaces between shaft and cylinder block into the casing, this leakage being returned to tank by a separate return line. There is also leakage over the same surface pair between the two grooves. The leakage paths are small clearances, in which the laws of viscous flow apply, i.e. leakage flow is proportional to pressure drop.

The auxiliary pump will supply a small amount of fluid to whichever of the two lines is at the lower pressure, i.e. to the return line if the load pressure P_L is positive, or to the forward line if the load pressure is negative. Hence for positive loads the effective flow is that in the forward line, while for negative loads the effective flow, i.e. the flow which must be used to calculate the speed of the motor, is that in the return line. If P_o is the base pressure, the pressures in the forward and return lines are $P_L + P_o$ and P_o respectively when $P_L > O$, and P_o and $P_o - P_L$ respectively when $P_L < O$. Leakage from the high pressure side to the other is $R_1 P_L$, while the leakage from either side to casing is $R_o P$, where P is the pressure in that side, where R_1 and R_o are constants, at least for a given oil temperature. The nominal delivery, i.e. the delivery when no leakage takes place, may be written Gx, where x is the

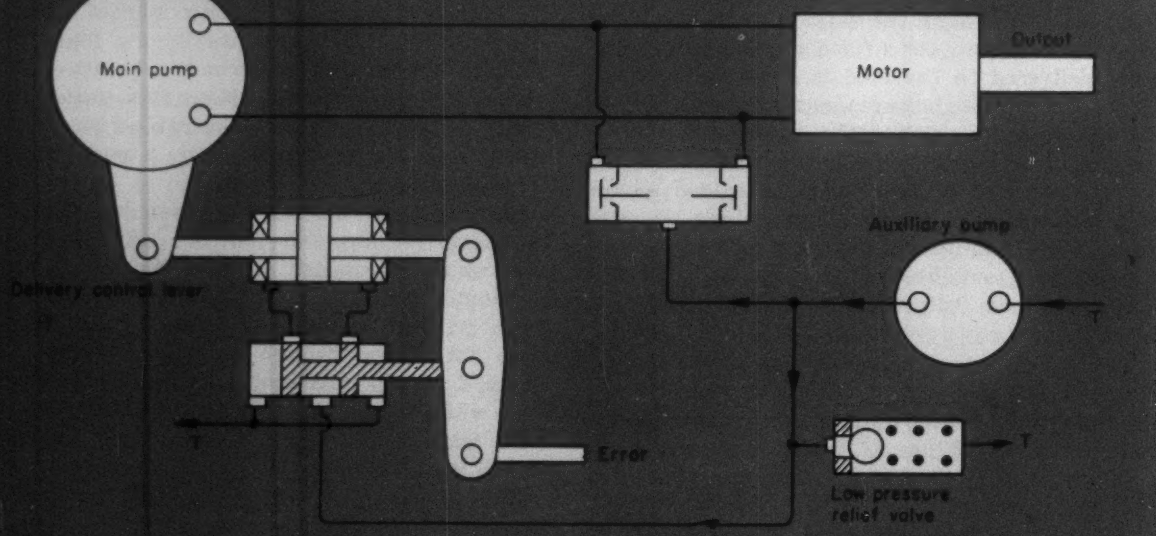


Fig. 56—Hydraulic circuit for orthodox variable delivery pump servo

displacement of the delivery control member.

The leakage on the forward side with positive load is $R_1P_L + R_o(P_L + P_o) = R_2P_L + R_oP_o$, where $R_2 = R_1 + R_o$. This leakage must be subtracted from the nominal delivery. Leakage on the return side with negative load is $-R_1P_L + R_o(P_o - P_L) = -R_2P_L + R_oP_o$, P_L being negative. This leakage must be *added* to the nominal delivery, since on the return side the total flow from the motor is the nominal pump delivery plus leakage. Thus the significant load flow Q_L is given by

$$Q_L = Gx - R_2 P_L \pm R_o P_o \qquad (22)$$

where the minus sign is taken for $P_L > O$ and the plus sign for $P_L < O$.

The resulting characteristic is shown in *Fig.* 58. The steps in the curve have an effect somewhat akin to backlash. If the load reverses on reversing the motion, there will be a small dead zone in the neighborhood of zero delivery, an effect which is confirmed by observation on actual servos. According to G. C. Newton Jr.[13], in some servomechanisms this effect is overcome by superimposing a high-frequency dither on the displacement signal applied to the pump, which can be done by a motor-driven eccentric.

As long as the backlash effect is solely due to the cause analyzed above, i.e. to the base pressure, there would seem to be another possible method of eliminating it, which is much simpler than dither. This method, not as yet tried as far as the author is aware, is illustrated in *Fig.* 59. The two commutation grooves (or "valve ports") are surrounded by a pair of full grooves, connected to the auxiliary pump, and therefore are kept at the base pressure P_o; the leakage from these grooves to the casing comes entirely from the auxiliary pump, and does not affect the delivery of the main pump, while the leakage from the latter is now as if P_o were zero.

If "backlash" is either eliminated or neglected, Equation 22 becomes simply

$$Q_L = Gx - R_2 P_L \qquad (23)$$

The constants G and R_2 correspond to the valve parameters denoted by the same symbols, except that in the case of the valve the parameters vary with valve opening and load. The pump constant R_2 does not, however, allow for any shunt across the motor.

Fifth part of this series, analysis of pump and valve servos, will appear in the February issue.

REFERENCES

12. J. F. Blackburn—"Contributions to Hydraulic Control"; "Pressure-Flow Relationships for a Four-Way Valve"; "Lateral Forces on Hydraulic Pistons," *Transactions of American Society of Mechanical Engineers*, New York, 1952.

13. G. C. Newton, Jr.—"Hydraulic Variable Speed Transmissions as Servo Motors," *Journal of Franklin Institute*, Volume 243, London, 1947.

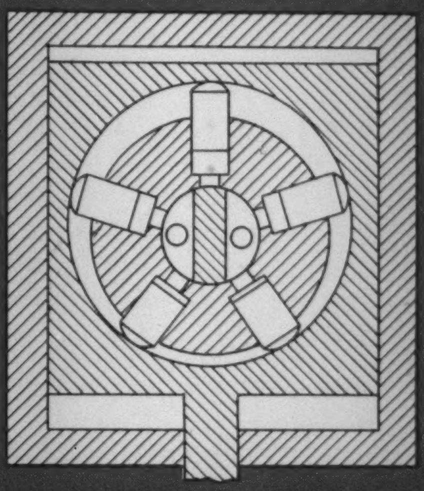


Fig. 57—Diagrammatic construction of variable delivery pump

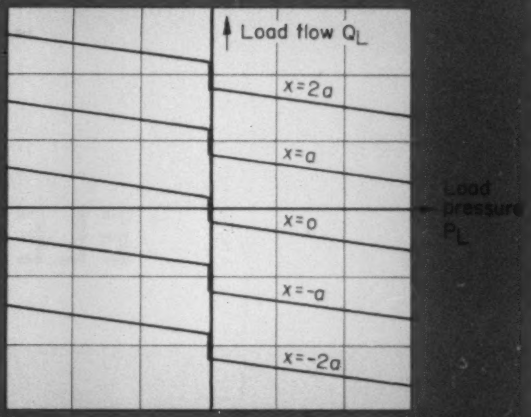


Fig. 58—Flow characteristics of variable delivery pump

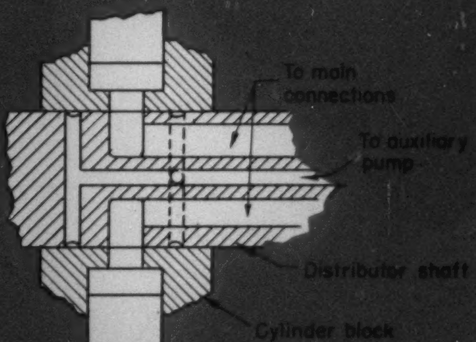
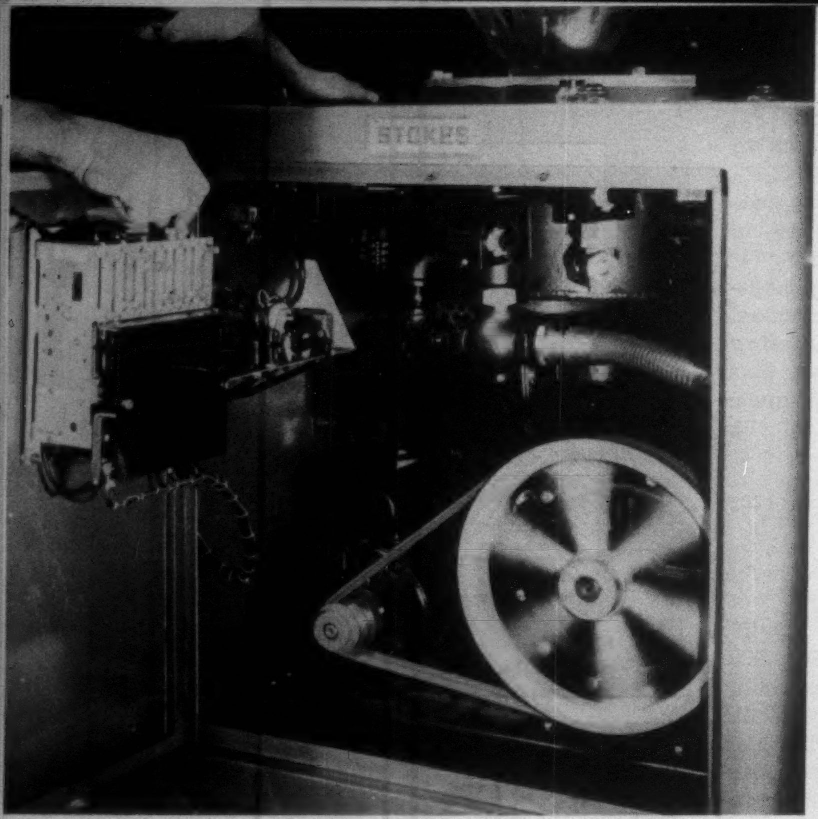


Fig. 59—Suggested antibacklash construction for variable delivery pump



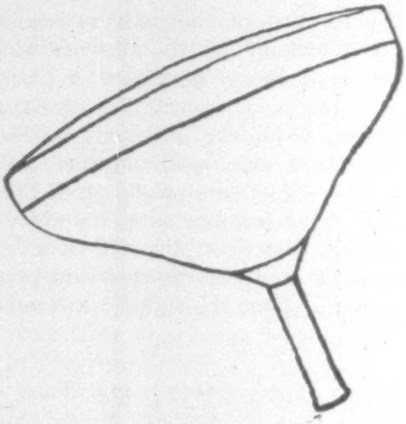
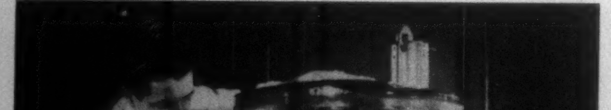


Fig. 1—All phases of the tube metallizing cycle are controlled by this sequence-type electrical timer, adjustable to 10-second intervals. Here, the operator changes settings of a micrometer adjustment on the timer which controls the duration of the flashing current

ELECTRICAL TIMER SEQUENCES

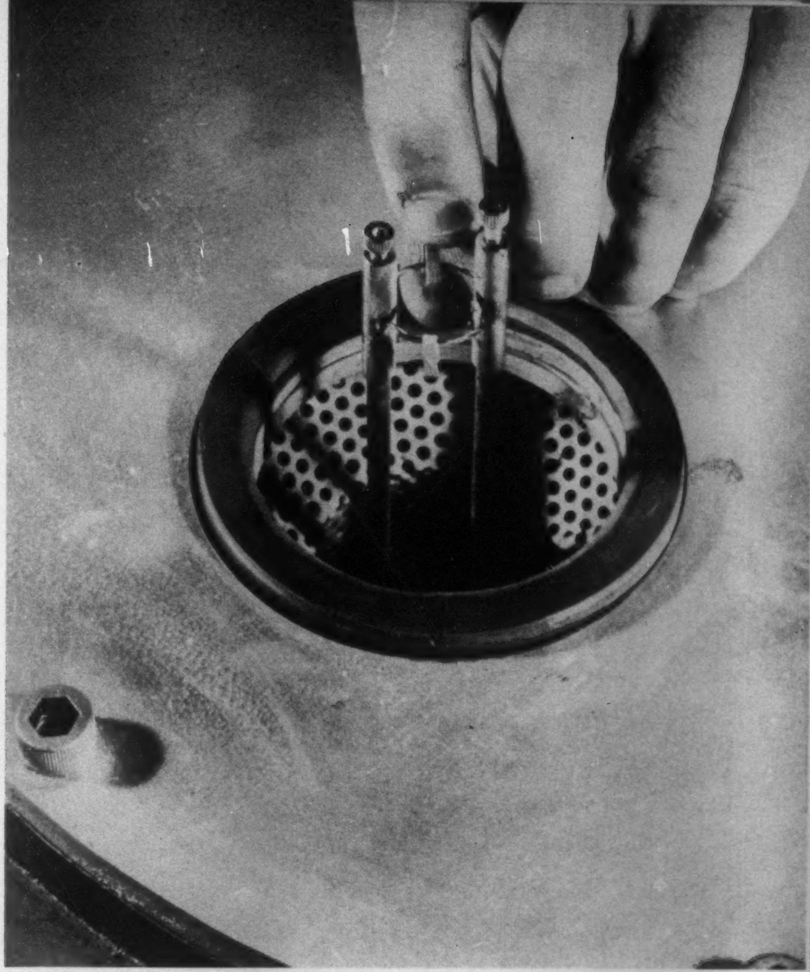


PRODUCTION PROCESSES in many industries utilize more and more the laboratory processes of yesterday. Vacuum plating—the transfer of metal by transforming it to the vapor state—is one of these processes that we can remember seeing at a science exhibit or reading about in academic literature. Automatic sequencing has turned this novelty into a production reality.

Metallizing the inner surface of TV picture tubes is done by this process. Automatic production can be achieved with a self-contained metallizing unit developed by the F. J. Stokes Machine Co. by means of an Eagle Signal Corp. sequence-type electrical timer. All operations—closing and opening of valves, starting and stopping of vacuum pumps, and switching on and off of vaporizing current—are controlled by this timer, *Fig.* 1. Once settings have been determined on the basis of preliminary tests, they need not be changed. One operator can supervise operation of as many as 10 units in addition to handling the loading and unloading of tubes into the equipment.

Fig. 2—Counterweighted yoke of the automatic lowering device fits around the flared sides of the tube and lowers the tube accurately into position, neck first, reducing tube breakage and handling time

Fig. 3—Before the uncoated tube is lowered into position, the operator places aluminum ribbon, in the form of short bent strips on the stranded tungsten filament. This aluminum vaporizes under vacuum and coats the entire inner surface of the tube with a thin layer of metal. A reflective surface behind the phosphors on the screen gives a brighter picture at lower exciting voltage



VACUUM METALLIZER

The uncoated tube is lowered, neck down, into the vacuum metallizing unit by an automatic lowering device, *Fig.* 2. The operator pushes one button to start the timer, and pays no further attention to the unit until the operation is finished.

Rough pumping stage of the cycle begins automatically. A vacuum valve opens between the evacuation chamber of the unit, into which the tube neck has been inserted, and a rotary mechanical vacuum pump, running continuously. Pressure in the tube is reduced to about 0.2 mm Hg in approximately 2½ minutes. At this preset time, an oil diffusion vacuum pump is cut in automatically and within 4 to 5 minutes further reduces pressure within the tube to that desired for vaporizing the aluminum to be deposited.

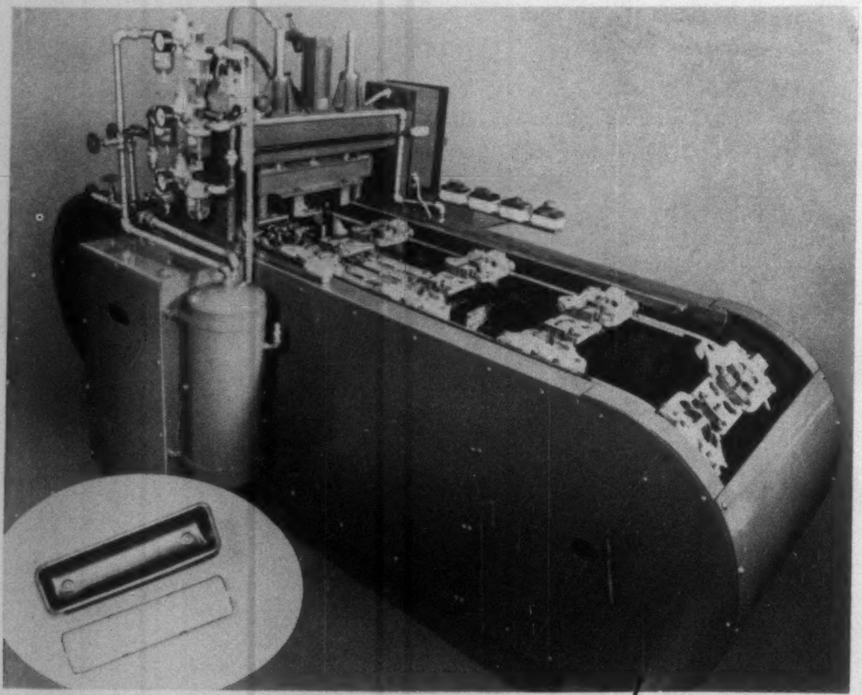
At this pressure the timer trips a switch that sends a 25-ampere pulse through a stranded tungsten filament, spanning the gap between two electrodes which extend into the neck of the TV tube. The filament carries several short, bent strips of aluminum ribbon which supply the metal source for the coating to be deposited, *Fig.* 3. As the aluminum melts, low pressure in the chamber vaporizes the molten aluminum, depositing a thin coating over the inner surface of the tube. Location of the metal source within the tube has been determined to provide uniform coverage by the metal film. Duration of the flash is controlled by a separate micrometer adjustment on the timer, calibrated in seconds, and lasts as long as required to give the required coating thickness. Filament power supply is a standard stepdown transformer and rheostat that converts normal 115-volt ac supply to low voltage, adjustable from 0 to 17 volts.

After flashing the electrical timer closes all vacuum valves and breaks the chamber and tube vacuum. The automatic device lifts the tube completely clear of the filament and the tube is ready for replacement. Another uncoated tube is lowered into place, and the cycle repeats at an average of one cycle in about 8 minutes, or better than 7 tubes per hour.

NEW EQUIPMENT

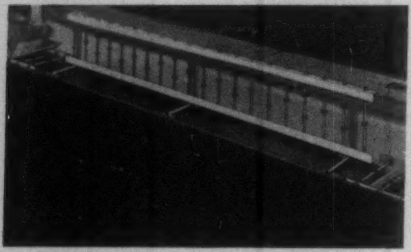
Machines and plant equipment designed for more automatic operation

AUTOMATIC RESISTANCE WELDING



Six hundred units per hour can be turned out by an automatic resistance welder. Built to weld retainers to valve gasket covers, machine utilizes a continuous conveyor chain to carry parts on twelve fixtures moving intermittently by means of an air cylinder. Air-operated stop pin gives positive location. As fixture enters the welding station, an air-operated clamping cylinder forces part downward, pushing fixture onto locating pins and forcing valve cover over the back-ups. Simultaneously twelve spot welds are made. **Multi-Hydromatic Welding & Mfg. Co.,** 23171 Groesbeck Highway, East Detroit, Mich.

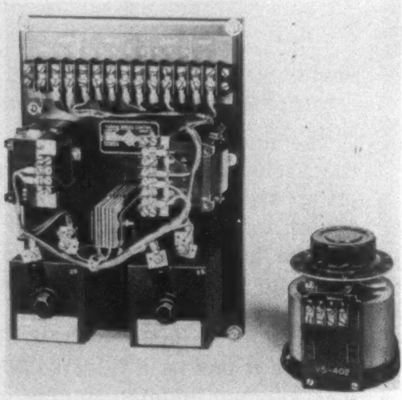
Circle No. 1 *on Reply Card*



WHEEL CONVEYOR

Small wheel conveyor is designed primarily for supermarket prepackaging meat rooms, but is adaptable for bench mounting in small parts and appliances assembly lines. Illustrated installation conveys meat from prepackaging through refrigeration to cold chest display, replacing bulkier old style conveyors. Unit conveys items with decreased angle of decline because of its light weight and easy turning wheel bearings. It is easily mounted on special brackets which allow any 5-ft section to be withdrawn for cleaning. Height from base to conveying surface is 1⅛-in., and width may be 10¾, 14¼, or 17¼-in. Lengths are 5 ft, with curves of 36, 48, or 60 in. outside the frame radius. Conveyor is available in zinc or cadmium plate, or frame. **Metzgar Conveyor Co.,** 408 Douglas St. N.W., Grand Rapids 4, Mich.

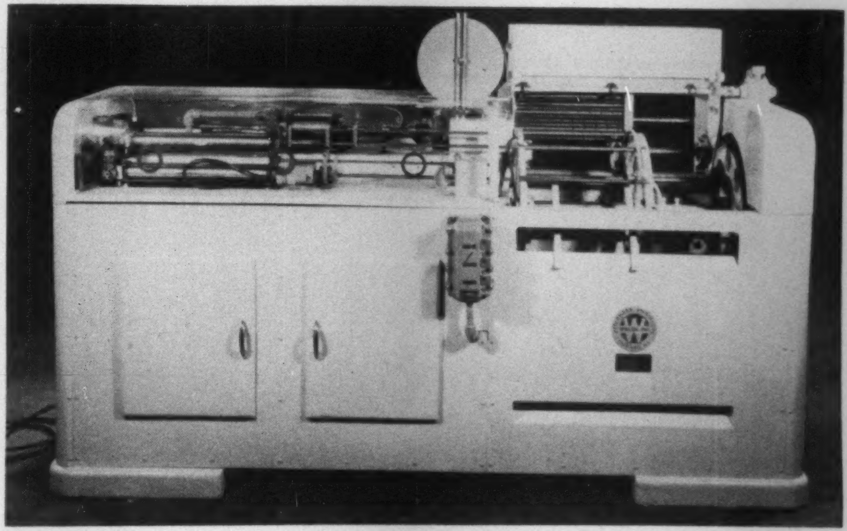
Circle No. 2 *on Reply Card*



MOTOR SPEED CONTROLS

Stripped down models of the Variac® motor controls, are available in sizes from 1/15 to 1½-hp. All parts except the speed control element are mounted on a metal chassis with connections brought out to a terminal strip. Only the Variac and switches are necessary at the control point, and various circuit arrangements can be used. General purpose control units operate dc shunt or compound motors from ac power lines. In addition to their wide speed range and high starting torque, they adjust smoothly, reverse quickly, are easily installed and maintained, and have no torque pulsation. They may be used as spindle and feed drives on machine tools, for jerk-free starting on winders and take-up drives, and for smoothly adjusting conveyor drives. **General Radio Co.,** 275 Massachusetts Ave., Cambridge 39, Mass.

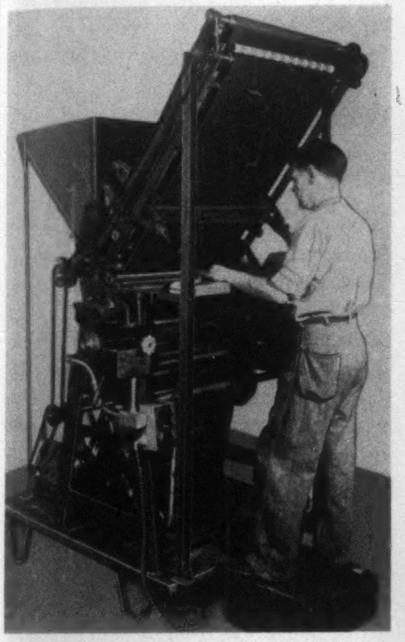
Circle No. 3 on Reply Card



DIAPHRAGMING FOR PRIMER

Automatic machine lacquers artillery primer body interiors, then punches diaphragms from rolls of paper, forms and installs them in the primer bodies. Diaphragms are set to required depth, inspected, and ejected automatically. Machine discards incomplete or rejected pieces. Ordinary manual insertion of diaphragm is slow and often inaccurate in that operator has difficulty locating lacquer at the proper position within the primer body for effective holding of the diaphragm. New machine's construction is of fabricated steel, with removable sides and a lucite cover over the cylinders. An inter-locking electropneumatic circuit operates air motors and rotary index table, controlled by microswitches. Primer bodies are fed into machine by a hopper which accommodates bodies from 3 to 24 in. long at speeds ranging from 20 to 50 pieces per minute. **Walsh, Inc.,** 646 N. Michigan Ave., Chicago 11, Ill.

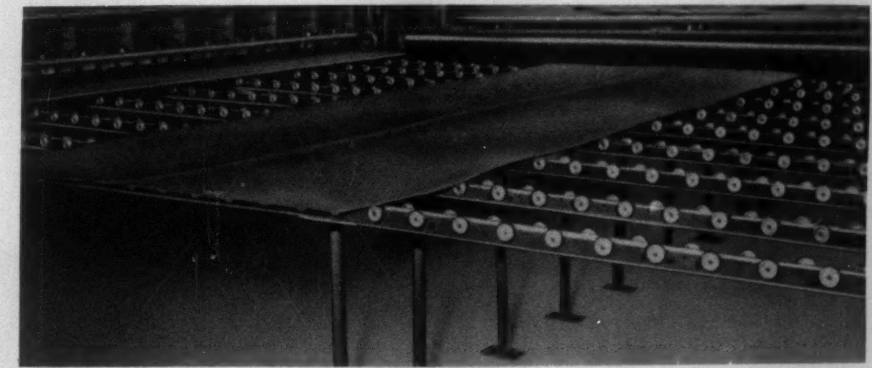
Circle No. 5 on Reply Card



TUBE LABELER

Available with either hand or automatic feed, this machine will label cylindrical paper tubes at the rate of 30 to 60 per minute. Speed is determined by a variable speed drive. Glue is applied to the label which is then forwarded mechanically to labeling station where it meets a tube which is time-fed from a hopper. Label is applied in accurate register. Traveling conveyor belts hold label onto the tube while the glue is setting. Machine can handle tubes with diameter of ¾ to 1¾-in., and hopper is adjustable to tubes ranging up to 27 in. in length. Complete glue coverage is assured. **Potdevin Machine Co.,** 285 North St., Teterboro, N. J.

Circle No. 4 on Reply Card

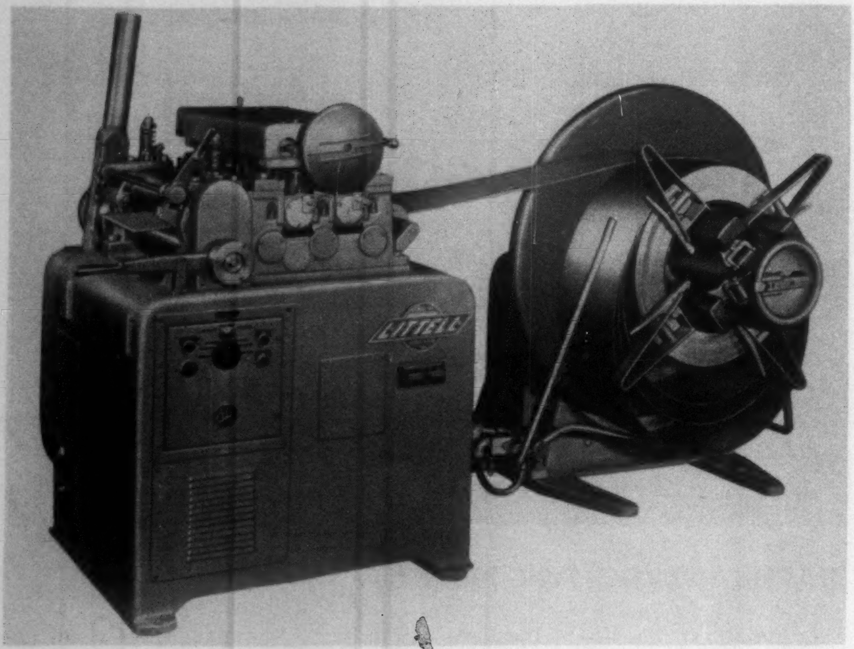


STEEL SHEET CONVEYOR

Sixteen foot flat steel sheets are moved from seam welder to roll former by live rail, wheel-type conveyors pitched slightly downward.

Illustration shows the installation of nine rows of two units, placed end to end, spaced about two feet apart and mounted on center supports. Sheets move semi-automatically by gravity from one operation to another. In-process storage bank and live feed-in table to the roll former are provided. Units come in 5 and 10 ft lengths, straight or curved, in single or assembled sections. **Pre-Engineered Products Div., Alvey-Ferguson Co.,** 21 Disney St., Cincinnati 9, Ohio.

Circle No. 6 on Reply Card



STOCK FEEDER

Stock is fed and straightened by a hydraulically driven feeding and straightening machine to convert manually operated punch presses to automatic operation. Stock can be as thick as 0.125-in. Three basic models are each equipped with five straightener rolls, 12½, 18½, and 24½-in. wide. Standard feed is 40 strokes per minute with lengths up to 19 in. Machine can be set in double cycle to feed up to 38-in. lengths at 20 strokes per minute. Proper synchronization of feeding and punching is assured by the wide range of feeding speeds available. **F. J. Littell Machine Co.,** 4127 N. Ravenswood Ave., Chicago 13, Ill.

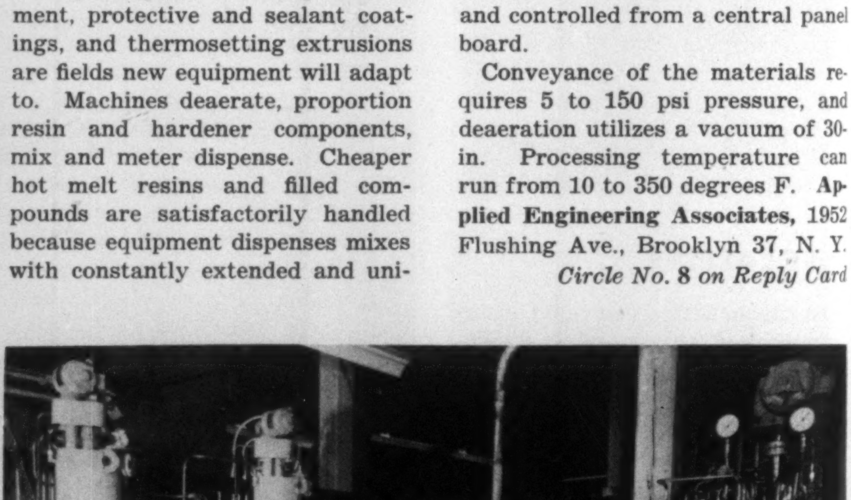
Circle No. 7 on Reply Card

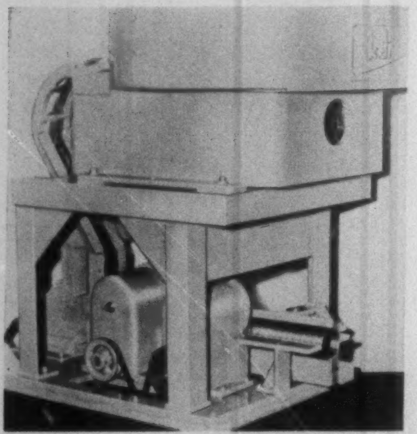
PROCESSING MULTI-COMPONENT RESINS

Processing of polyesters, epoxies and other multi-component resins can now be handled on a production line basis with a new line of automatic equipment. Laminating, mat molding, matched die molding, plastic tooling, adhesives and sealers, potting and casting embedment, protective and sealant coatings, and thermosetting extrusions are fields new equipment will adapt to. Machines deaerate, proportion resin and hardener components, mix and meter dispense. Cheaper hot melt resins and filled compounds are satisfactorily handled because equipment dispenses mixes with constantly extended and uniform pot life. Deaeration by film evaporation, ingredient proportionment by volumetric measuring without use of gears or pumps, mixing by agitation - homogenization are featured. Reciprocating pump meters the finished mix. Operation's variables are indicated and controlled from a central panel board.

Conveyance of the materials requires 5 to 150 psi pressure, and deaeration utilizes a vacuum of 30-in. Processing temperature can run from 10 to 350 degrees F. **Applied Engineering Associates,** 1952 Flushing Ave., Brooklyn 37, N. Y.

Circle No. 8 on Reply Card





BEARING RACE FEEDER

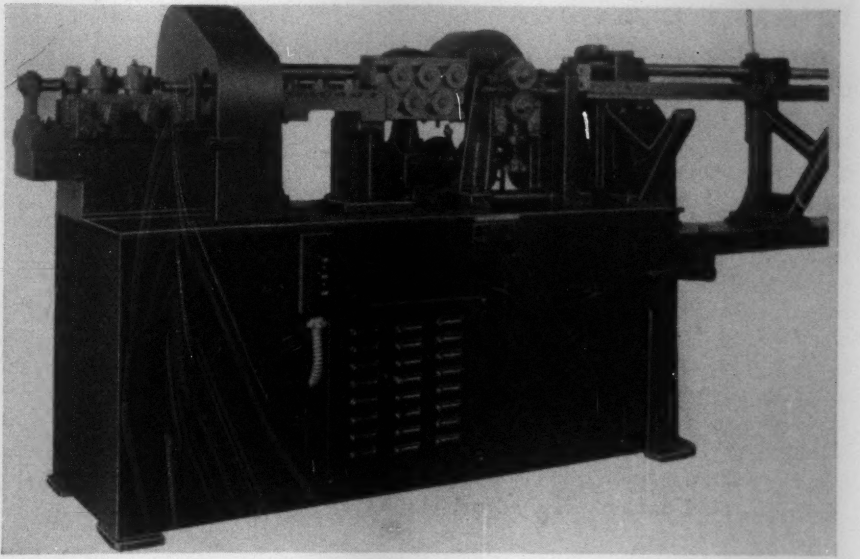
This new, automatic Thru-Feeder is designed to automate centerless grinding operations for bearing races. Parts are hopper fed to a stacking device which aligns them and feeds them into a dual pair of feed disks, which carry parts to the grinder work rest. By maintaining a constant and predetermined pressure, the machine maintains squareness and taper requirements on the parts. Carbide wear inserts are incorporated on all four guide rails. Two models accommodate races or similar parts ⅜ to 1¼-in. in diameter, or 1¼ to 3 in. in diameter. **Kraus Design, Inc.,** 977 Exchange St., Rochester 8, N. Y.

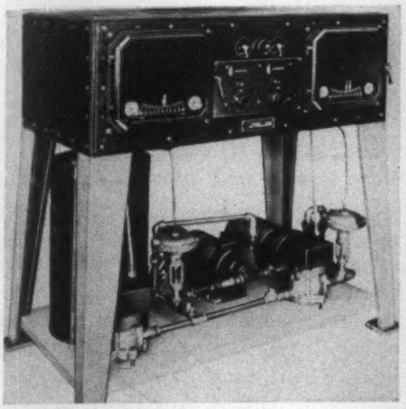
Circle No. 9 on Reply Card

WIRE CUTTING

This new wire straightener and cutter automatically handles 3/16 to ¼-in. square or hex wire, or flat wire ranging from 1/16 x ¼-in. to 3/32 x ½-in. Multiple sets of straightening and feeding rolls handle wire uniformly on long production runs. Machine cuts to predetermined lengths accurately by means of instantaneous clutch and cutoff. The almost continuous wire movement minimizes marking and assures square cut ends. In addition to automatic controls, unit features ball and roller bearings and V-belt motor drive. **Mettler Machine Tool, Inc.,** New Haven, Conn.

Circle No. **10** *on Reply Card*





AUTOMATIC BLENDER

A two component blender provides a complete equipment package for on-stream blending. Blender is available in two models: a flow responsive blender which automatically varies its output to process demand, and a controlled rate blender which maintains a preset blend rate exactly. Equipment is applicable to caustic dilution, asphalt blending, cutting of heavy fuel oil, and blending of butane and gasoline. The uniform blend is automatically delivered directly to tank trucks, tank cars, ships, or storage. It may be duplicated with accurate uniformity for any number of batches and produced as needed, eliminating added tank storage, mechanical mixing, stratification. **Proportioneers, Inc.,** 345 Harris Ave., Providence, R. I.

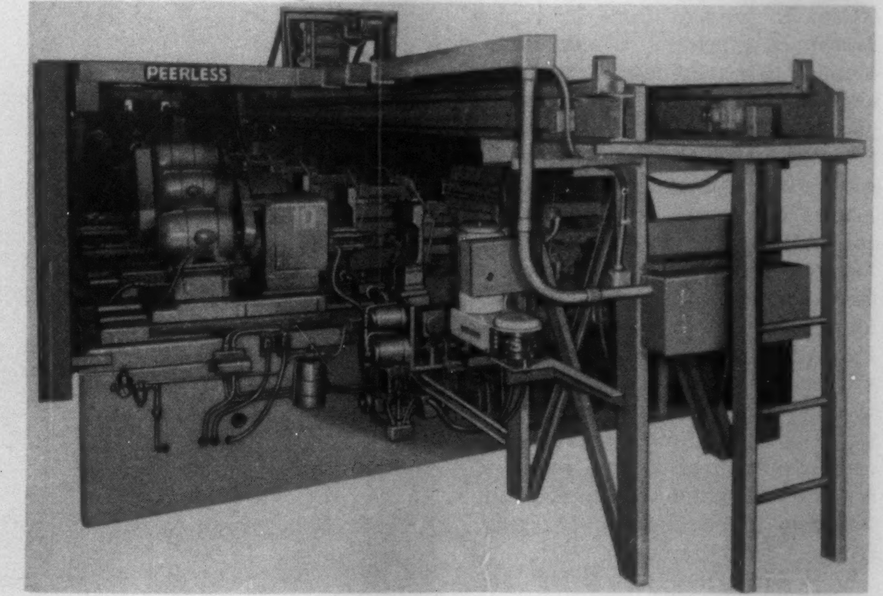
Circle No. **11** *on Reply Card*

CARRIERS PROCESSED AUTOMATICALLY

An automatic transfer machine processes differential carriers, replacing an entire department of machines and operators. Starting with raw cast carriers, the unit roughs, finishes, bores, faces, drills and taps the workpieces, all the while holding precision boring and facing tolerances. Although built to handle this particular assignment, machine's design provides for flexibility of an individual operation set-up. The automatic unit, as currently operating in an axle plant, processes 40 heavy truck-axle carriers per hour. It has eight stations in all, five working, one loading and unloading, and two idle. Pallet movement is hydraulically actuated and overhead pallet-return conveyor and elevators are power operated.

The feed unit is 17-in. way-floor-type and bore face is hydraulically driven. Colored light push-button control panel permits operational check. Other equipment includes single-place pallet fixtures with power clamping, fixed-center ball-bearing drillheads, and individual lead-screw tapping head. **Peerless Production Co.,** 19449 Glendale, Detroit, Mich.

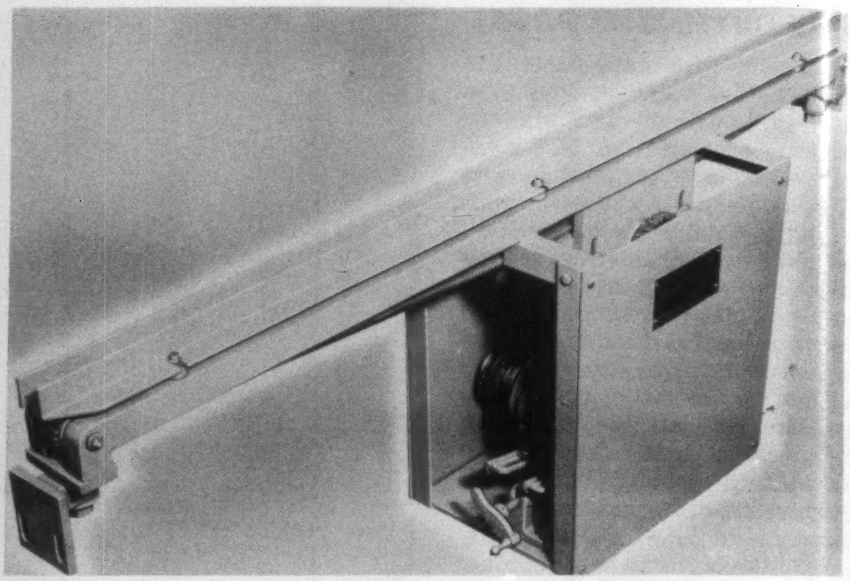
Circle No. **12** *on Reply Card*

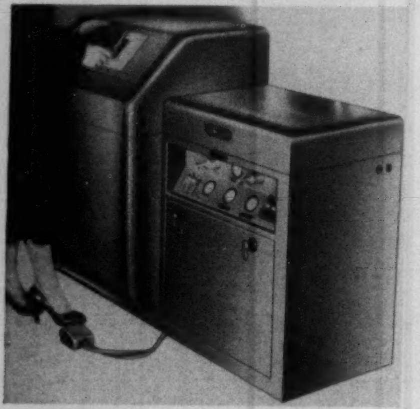


TRANSFER CONVEYOR

Cylindrical work is through fed to centerless grinders and special polishing or inspection machines by this transfer conveyor. Drive mechanism is powered with a 1/4-hp, 220/440 v, 3-phase motor. Variable speed drive controls feed rate, and the standard conveyor has a feed range of 7 to 28 fpm. Illustrated model is designed for work 1/4 to 1 1/2-in. diameter, and is 60 in. long. Machines are available in various lengths and for various size workpieces. **Feedall Machine & Engineering Co.,** Willoughby, Ohio.

Circle No. **13** *on Reply Card*





SPRAY MASK PAINTING

Three-dimensional quality finishes are claimed for this automatic spray painting machine. Spray is completely enclosed within the machine, and ventilating and ducting devices prevent vapor escape. Air flow across spray passage is controlled to prevent fume or vapor deposit on guns and to hold maintenance to a minimum. Travel and angular adjustment of spray guns permit for distinct angular spray patterns per cycle to eliminate shadowing and assure uniformity. Angles are controlled by mechanical linkage and an air cylinder. Automatic timer adjusts any cycle from a fraction of a second to as long as necessary for coverage. Pneumatic drive has a hydraulic system governing speed of travel throughout cycle for controlled spray pattern. Simple adjustments control length of stroke, width of spray, and angle of application. **Sepanski & Associates,** 900 Clancy, N. E., Grand Rapids 5, Mich.

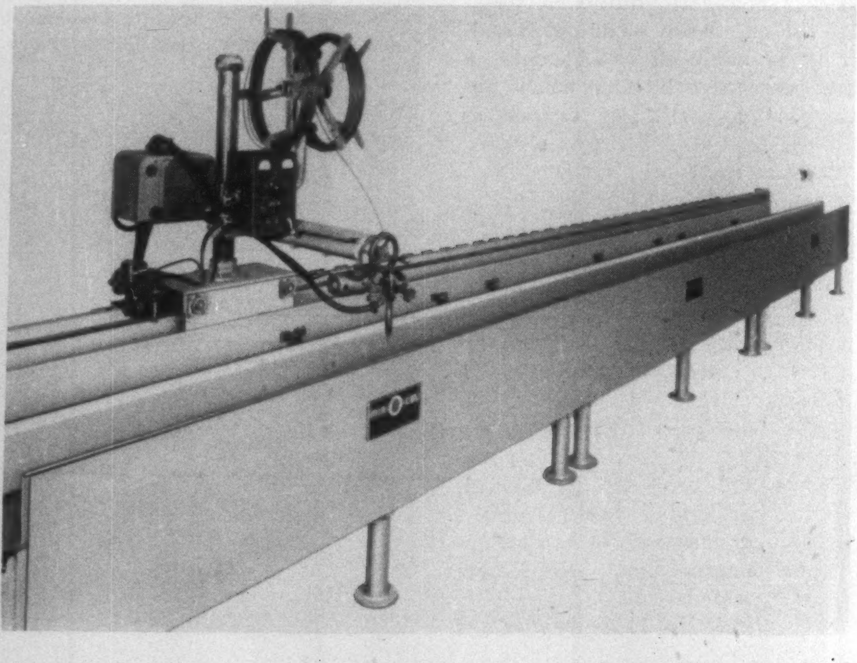
Circle No. **14** *on Reply Card*

RAIL WELDING-REBUILDING MACHINE

Rail builder is designed to rebuild or hard-face extra heavy and large sections such as cat tracks, shovel pads, grader and dozer blades, and to fabricate large sections such as pipe, I-beam, and structural pieces. It will weld 1 to 100 in. of bead per minute. Table is 30 ft long to accommodate long pieces, 32 in. wide, 7 in. deep, and 32 in. from the floor for easy loading. Power for the submerged arc welder is supplied by a 625 amp constant potential unit. Welding head is mounted on a traverse arm which can swing in a full 360° circle. Starting and stopping arc and flow of wire is automatic. While welding tracks, operator can preset cam trips to automatically cut off power as head passes between links.

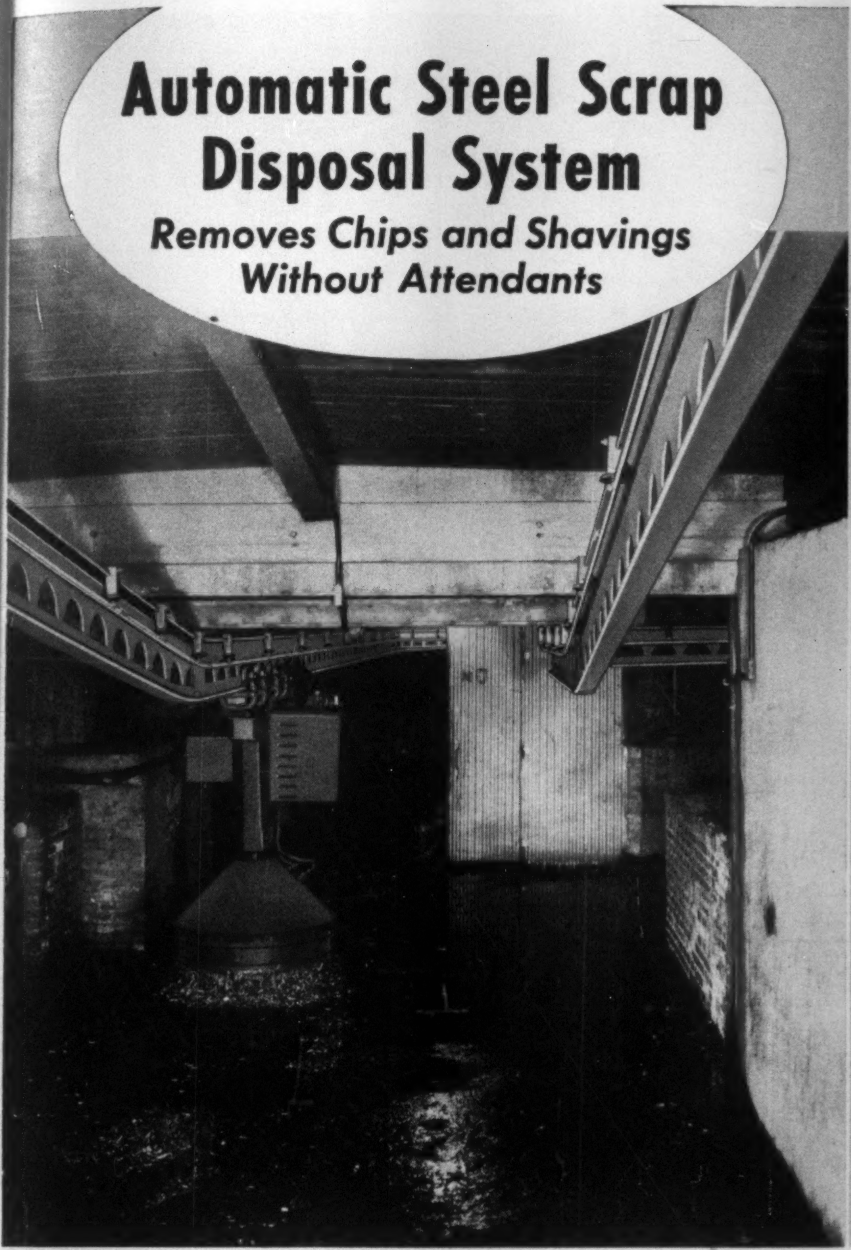
Single lever shifts the cam trips so that opposite side of track can be rebuilt without setting each cam. Variable speed motor and adjusting wheels permit stopovers as small as 1/64-in. and fine vertical adjustment. **Mir-o-col Alloy Co.,** 312 North Ave. 21, Los Angeles 31, Calif.

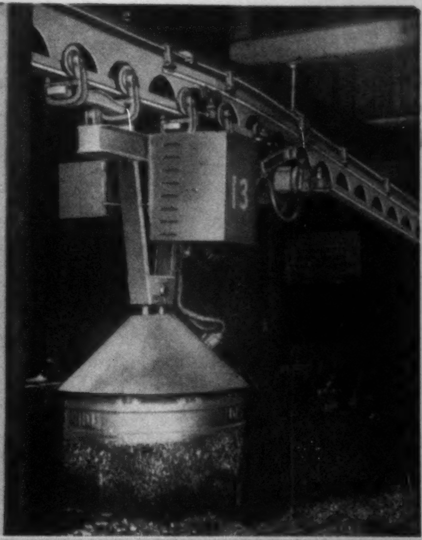
Circle No. **15** *on Reply Card*



Automatic Steel Scrap Disposal System

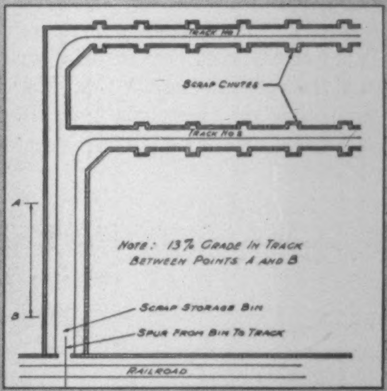
Removes Chips and Shavings Without Attendants





View of tracks near beginning of tunnels. Carrier is shown approaching track incline on way to bin with a load.

A load of scrap about to be dropped in bin. Carrier immediately reverses after unloading and starts another trip.


TRACK No 1
SCRAP CHUTES
TRACK No 2
A
B
NOTE: 13% GRADE IN TRACK BETWEEN POINTS A AND B
SCRAP STORAGE BIN
SPUR FROM BIN TO TRACK
RAILROAD

ONE carload of metal chips and shavings is picked up and moved daily with an automatic Cleveland Tramrail magnet-carrying system that operates unattended in two parallel tunnels under metal-working machines.

Each tunnel has its own Tramrail track on which a magnet carrier travels back and forth, picking up scrap that comes down from the machines on floor above. The scrap is conveyed to a bin next to a railroad siding. The system was put into operation in 1942 and has proven an extremely efficient and low-cost method for ferrous scrap disposal.

CLEVELAND TRAMRAIL
ENGINEERING AND APPLICATION DATA

GET THIS BOOK!
BOOKLET No. 2008. Packed with valuable information. Profusely illustrated. Write for free copy

CLEVELAND TRAMRAIL DIVISION
THE CLEVELAND CRANE & ENGINEERING CO.
1385 EAST 284th ST. *WICKLIFFE, OHIO*

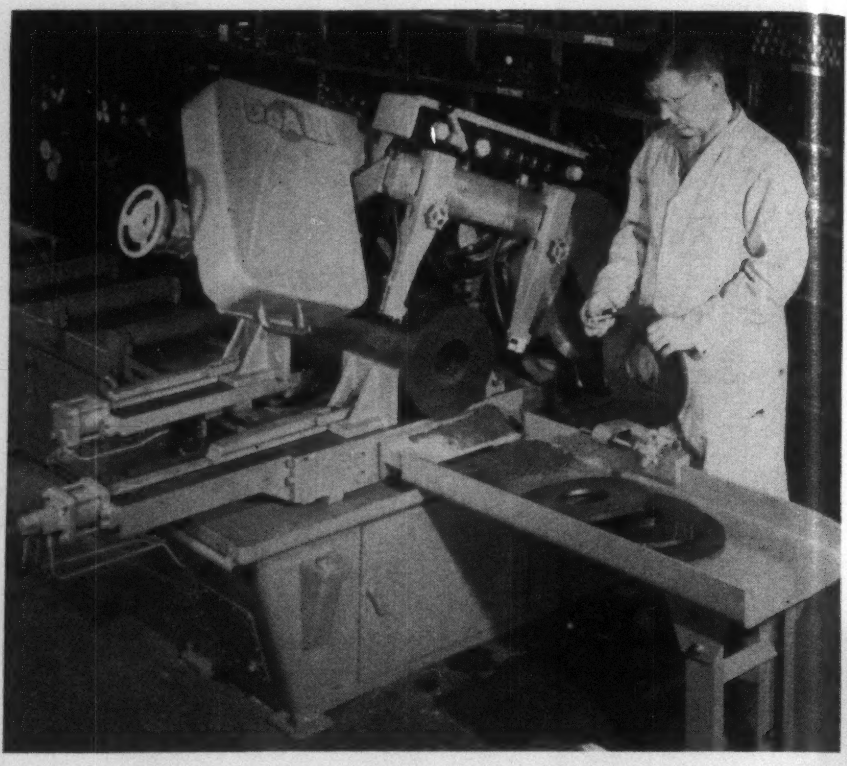
CLEVELAND TRAMRAIL
OVERHEAD MATERIALS HANDLING EQUIPMENT

POWER SAW

Hydraulic controls for feed pressure, band tensioning, and infinitely variable speed change are featured on a new, high speed steel saw for manual or fully automatic operation. With standard automatic index, the saw cuts blanks up to 24 in. long, but can be modified to handle any reasonable length blank. A continuous band tool moves always in a cutting direction, and material waste is prevented because of narrow path cut by slender saw band. Automatic feed pressure control maintains the pressure set by operator, automatically compensating for greater resistance and allowing adjustment for optimum production commensurate with tool life, accuracy, and finish requirements. Variable tool speeds range from 90 to 350 fpm. Regulated at the factory, hydraulic control maintains the blade tension.

All control levers and knobs are on a panel on the saw head. Operator can adjust direction of saw head, sawing or feed pressure (hydraulically maintained by machine afterward), blade speed, rate of coolant flow, and automatic or manual indexing. **DoAll Co.,** 254 N. Laurel Ave., Des Plaines, Ill.

Circle No. **16** *on Reply Card*

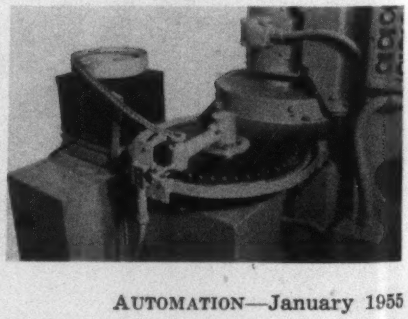


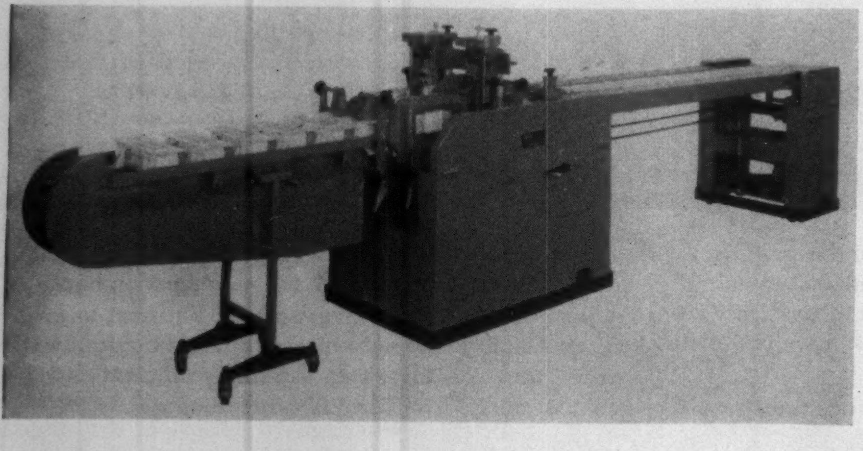
OIL PUMP RING GRINDER

Only manual operation in an automatic grinder which turns out 1200 to 1400 oil pump eccentric rings per hour is the loading and emptying of hoppers. Rings are hopper fed into a continuously rotating feed wheel which carries them between two abrasive wheels. Both faces are ground at once and maximum stock removal is 0.009-in. Accuracy is held to 0.002-in. for size and to 0.0003-in. for flatness and parallelism. Rings are then unloaded into a discharge pan by gravity.

A radially mounted arm releases a limit switch and breaks electrical circuit to the fixture drive motor should a part fail to enter the feed wheel properly, thus insuring proper loading. Grinder adapts to small parts such as magnets, snap rings, bearing races, chain saw parts, ceramic washers and insulators. **Besly-Welles Corp.,** Beloit, Wis.

Circle No. **18** *on Reply Card*





CARTON GLUE SEALING MACHINE

Semiautomatic glue sealing machine for cartons applies glue in any desired pattern to any or all flaps of the carton via vertical glue wheels. Uniform application assures a neat, clean seal and a positive inner seal. Glue rollers and scrapers are easily removed for fast maintenance and cleanup. Simple adjustment changes machine over to different size and shape cartons and changeover operation takes less than three minutes.

Variable speed controls adjust to requirements, and entire machine is mounted on casters. **Container Equipment Corp.,** Locust Ave., Bloomfield 2, N. J.

Circle No. **17** *on Reply Card*

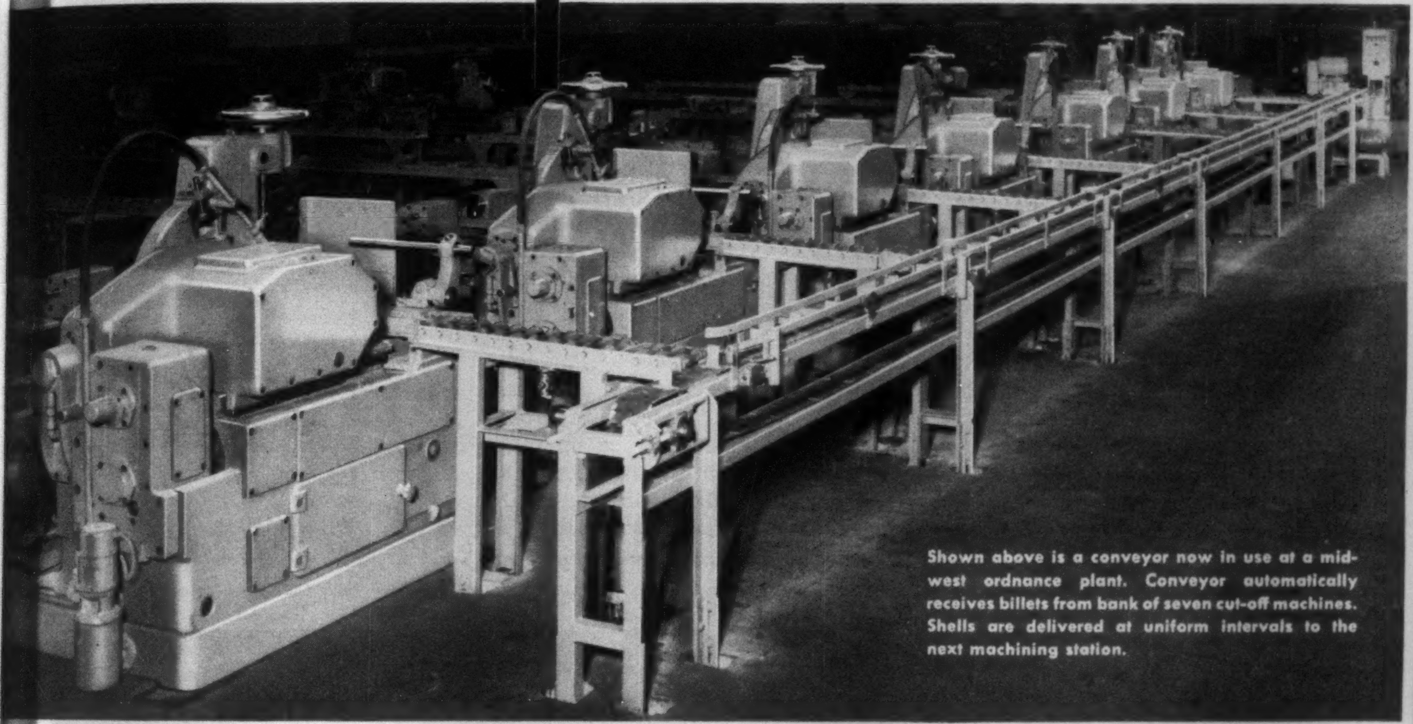
"PRACTICAL ENGINEERED" CONVEYORS...

now designed and built to fit your needs

IMPORTANT PART OF AN EXPANDED BUILDING SERVICE FOR AUTOMATION EQUIPMENT

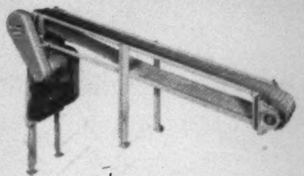
The Process Equipment Division of the W. F. & John Barnes Company now provides complete facilities for designing and fabricating standard or special conveyor units and systems. The four units illustrated are typical of the hundreds of conveyor installations designed and built from standard components to meet the exact need of the particular job to be done. Every Barnes unit is a "tailor-made" system that is "practical-engineered" to increase work handling efficiency by eliminating the more hazardous and laborious manual operations.

Here at Barnes, you'll find the varied engineering and creative skills, plus over 75 years of machine building background, to help you solve many troublesome production problems. And, because all planning, engineering, and manufacturing efforts are closely coordinated, you have available a complete "Automation Equipment Service" from one convenient source.



Shown above is a conveyor now in use at a mid-west ordnance plant. Conveyor automatically receives billets from bank of seven cut-off machines. Shells are delivered at uniform intervals to the next machining station.

A leading automotive manufacturer uses this Barnes Conveyor to carry cast iron chips away from machine tools. Chips are carried on a heavy drag-type conveyor-elevator and dropped in a tote box.



Shown here is a wire-mesh type, variable speed conveyor designed for carrying small work parts from a machine. It is widely used for general work-handling and can be built to handle the required length and width of the workpiece.

Here is a Barnes Conveyor in operation on an appliance production line. Metal cylinders are moved by the conveyor through a washer to the next point of operation.

ASK FOR AN ANALYSIS OF YOUR WORK-HANDLING PROBLEMS

Find out how these unique creative and specialized resources can help you cut costs. Your problem will be given expert and individual attention.

GET THIS NEW BROCHURE

Write today for copy of Conveyor Units and Systems. You'll find 27 solutions to material handling problems.

W. F. & JOHN BARNES

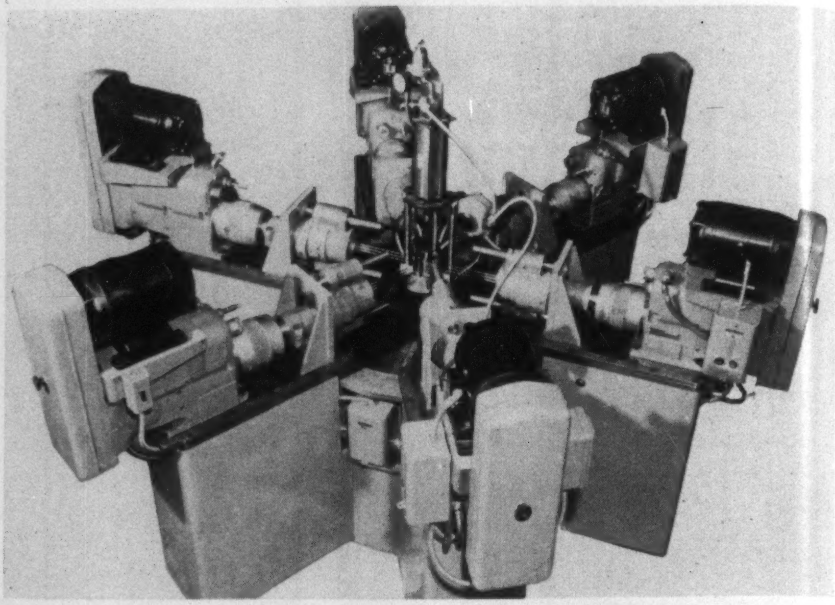
W. F. & JOHN BARNES COMPANY *Process Equipment Division*
414 SOUTH WATER STREET • ROCKFORD, ILLINOIS

BUILDERS OF BETTER MACHINES AND EQUIPMENT SINCE 1872

MULTIPLE SPINDLE DRILLING

Multiple spindle drill can bore 18 holes, 3/16-in. diam, simultaneously in a hollow spindle. Operation is completely automatic and operator merely positions workpiece. Machine has capacity of 400 piece parts per hour. Coolant tank and extra-heavy duty pump for flooding fixture for cleaning are included. **Gordon & Morgan Machine Co.,** 3725 Touzalin Ave., Lincoln, Neb.

Circle No. **19** *on Reply Card*



CONTINUOUS MIXING

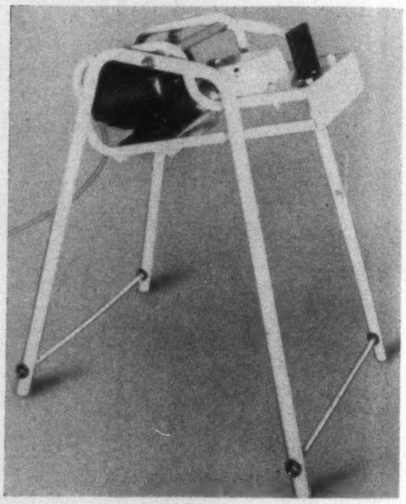
Material ranging in size from minute particles to approximately 1½-in., in either a dry state or in a slurry, can be handled by a line of continuous type mixing and pugging machines. Equipment is applicable to metal producing, chemical, and food processing industries, and to foundries and mills. Mixers can be provided with capacities to suit specific requirements. The continuous mixing process provides greater production and increased batch sizes, as well as minimizing blade wear because of light loads in the trough. Welded frame is of heavy steel plate, and replaceable mixer trough is of heavy-gage material. Box-type construction eliminates dirt catching framework, and a safety guard covers the mixing portion of the trough. Mixer is equipped with a simplified drive mechanism and standard frame motor. Diversion plate eliminates segregation tendencies. **Colonial Iron Works Co.,** 17643 St. Clair Ave., Cleveland 10, Ohio.

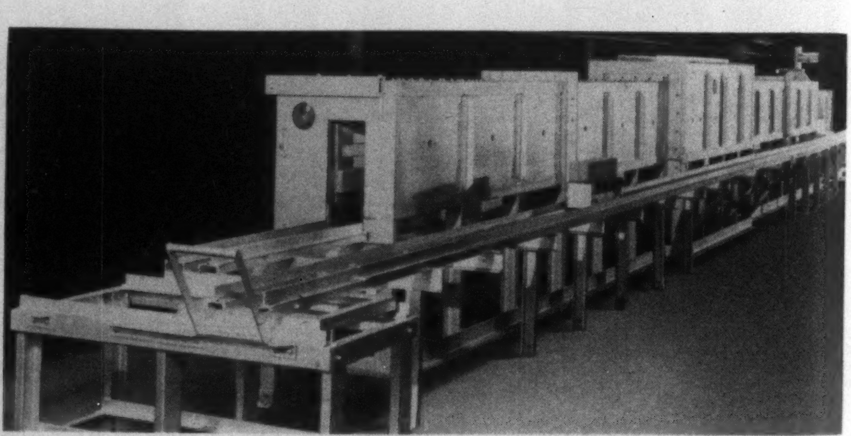
Circle No. **20** *on Reply Card*

SCRAP CHOPPER

Feed systems for roll stock on punch presses do not jam when this new scrap chopper is utilized. Chopper is suspended to float freely from its base. When the waste stock passes through the cutting slot, chopper rocks down with the jump of the stock, cuts, rocks back up. All back pressure is eliminated and stock is not bowed. Portable unit may be moved from one press to another, and cutters are interchangeable. Stock can be up to 3 in. wide and 0.05 in. thick. **Dept. 3, Northeastern Development Engineers,** 21 High St., Pawtucket, R. I.

Circle No. **21** *on Reply Card*

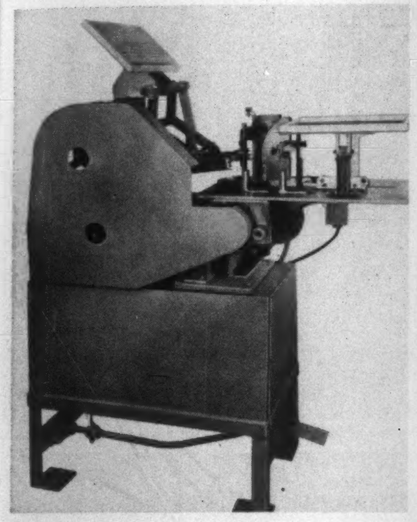




TUNNEL KILN FOR CERAMICS

Automatic charging is available on a new car type tunnel kiln, which will allow one shift to prepare work that can be processed automatically through the remaining two shifts without an attendant. Kiln produces the consistent electrical characteristics necessary for ceramic component requirements in the electronics industry. It is designed for use with special atmospheres for continuous firing of titanates, ferrites, and other special ceramics. Illustrated kiln has a loading cross section 6 in. wide and 8 in. high. Overall length is 56 ft, including loading, preheating, firing, cooling, and unloading sections, and actual furnace tunnel is 41 ft. Equipment produces 80 lb per hour when firing at 2500 F on a 7-hour cycle. **Harper Electric Furnace Corp.**, 39 River St., Buffalo 2, N. Y.

Circle No. 22 on Reply Card

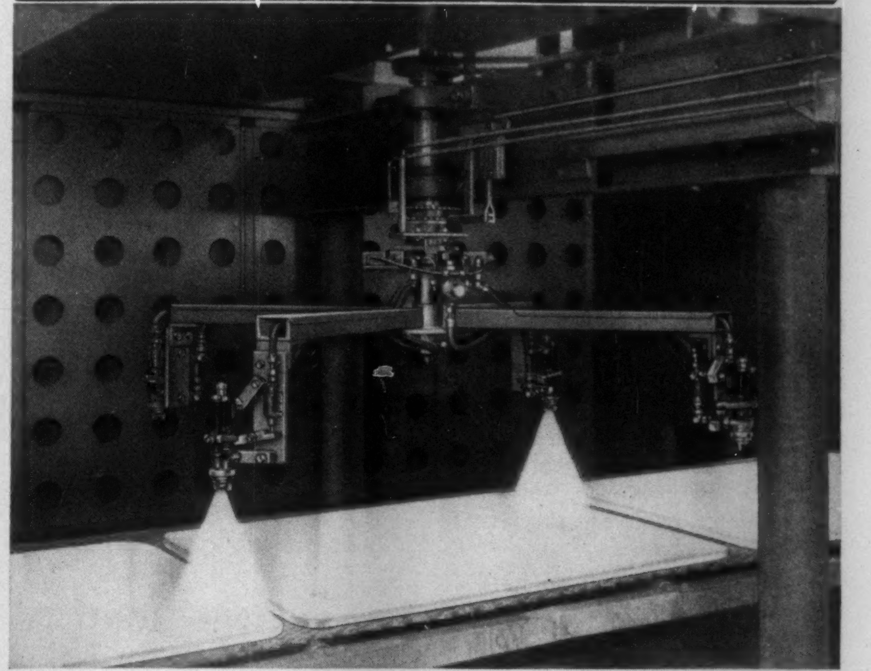


PRINTING MACHINE

Trade name, trade mark, specification are automatically printed on small cylindrical objects with wire leads such as resistors, condensers, capacitors, diodes, triodes, transistors and sub-miniature electronic tubes. Printing machine includes a chute feed which adjusts to handle items up to 2½-in. long and ¾-in. OD, and will adjust to any variation in a given diameter. Special adapter facilitates easy change in data printed and eliminates need for etchings, plates, etc. Inks come in various colors for various materials and finishes. Imprint can be transferred anywhere on the printed object. Powered by a ¼ hp motor equipped with variable speed drive, entire unit is only 45 x 15½ x 56-in. **Markem Machine Co.**, Congress St., Keene 40, N. H

Circle No. 23 on Reply Card

WHAT'S NEW in automatic spray painting



New rotary spray painting unit finishes flatware at 100 ft./min.

This new automatic rotary spray painting machine has three major advantages over previous automatic equipment: (1) It applies uniform coatings at extremely high conveyor speeds. Outstanding results have been obtained with the conveyor running as fast as 100 feet per minute. (2) The thickness of the coating can be closely controlled by varying the speed of the rotary head. This is easily done with the precise built-in variable speed drive. (3) Maintenance is greatly reduced. There are fewer moving parts in the new rotary machine and they travel continuously in one direction at slower speeds, reducing vibration, wear.

OVERSPRAY REDUCED TO MINIMUM

The four automatic guns operate only when they are directly over the ware. Each turns on automatically when it reaches the edge of the product and shuts off as it leaves. The length of time the guns are in operation can be controlled to accommodate products of various widths. This adjustment can be made while the machine is in operation.

FOR FURTHER INFORMATION

If you think this new machine may have a place in your plant, Binks will gladly analyse your operation and make a specific recommendation. There is absolutely no obligation. Just write direct to the address below:

Binks
EVERYTHING FOR
SPRAY PAINTING

GUNS
SPRAY BOOTHS
FREE INSTRUCTION

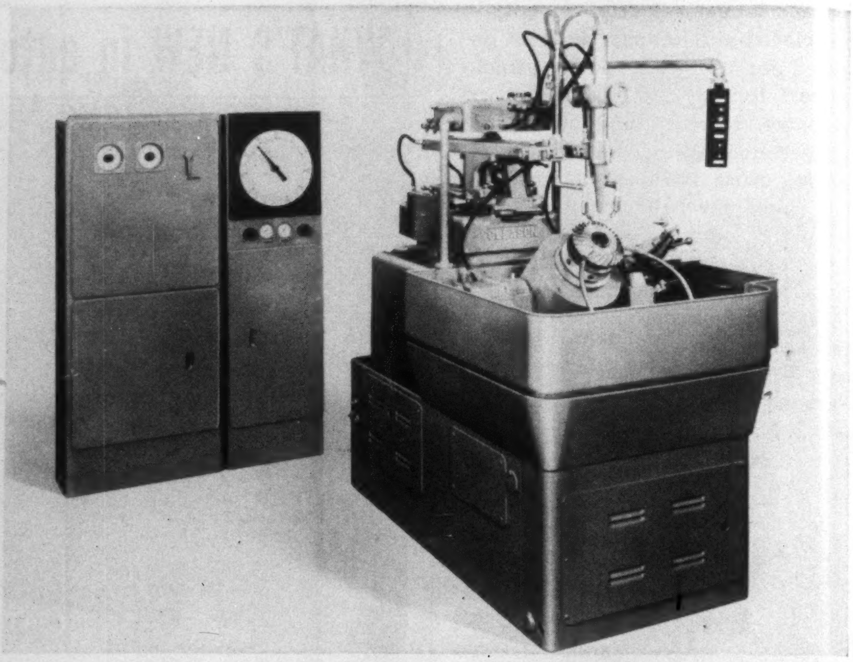
BINKS MANUFACTURING COMPANY
3126-30 Carroll Ave., Chicago 12, Illinois

REPRESENTATIVES IN PRINCIPAL U. S. & CANADIAN CITIES • SEE YOUR CLASSIFIED ☎ DIRECTORY

GEAR HARDENER

Oxy-acetylene flames traverse each individual gear tooth separately in a new gear surface hardener which features an electronic control mechanism. A radiation pyrometer is focused directly on the tooth being heated and receives radiant energy from the hot metal. The electronic balancing mechanism translates that energy into signals which control the travel of the burners along the tooth. Once the optimum hardening temperature is preset by operator and machine is started, operation is entirely automatic. Variety of steels, both forgings and castings, can be surface hardened on these machines without any change in chemical composition. Only the gear teeth are heated so that there is no distortion, and region of hardness is limited to the wearing surfaces. Machines are indexed so that the teeth hardened successively are nonadjacent to eliminate any change in bore diameter during hardening. Self-quenching nature of this method minimizes internal stresses. Units can be arranged to use water or oil quenching if desired, and coolant streams can be directed as close to or as far from the heating point as desired. Special burners with cooling orifices can be provided for use on coarse pitch teeth. These surface hardeners will process the teeth of straight bevel, spiral bevel, Zerol, spur, herringbone, or helical gears. **Gleason Works,** 1000 University Ave., Rochester 3, N. Y.

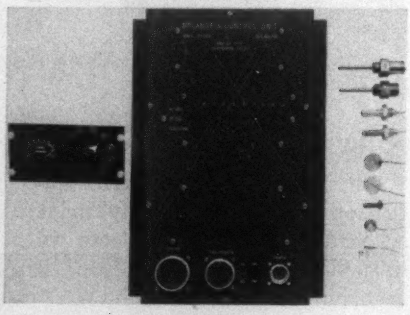
Circle No. 24 on Reply Card

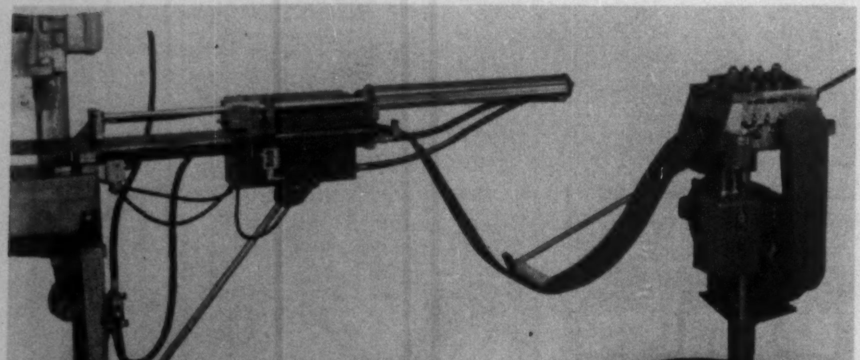


TEMPERATURE MONITOR

A temperature measuring, indicating, and warning system is suitable for industrial, airborne, and laboratory use. It monitors critical temperatures at many locations simultaneously, providing instantaneous warning of circuit temperature changes above or below a predetermined value. When a critical point is reached, an indicator lamp flashes on and remains lit until normal temperature is regained. Indicator panel meter can be read directly in percentage of critical temperature, and is calibrated with dial markings of from 50 to 120 per cent. Balance and power unit contains all necessary circuitry, supplies power for probe excitation, and contains adjustments for setting range, span, and warning temperature of each channel. **Dept. AT-2, Arnoux Corp.,** 1357 S. Hawthorne Blvd., Hawthorne, Calif.

Circle No. 25 on Reply Card





SLIDE FEED

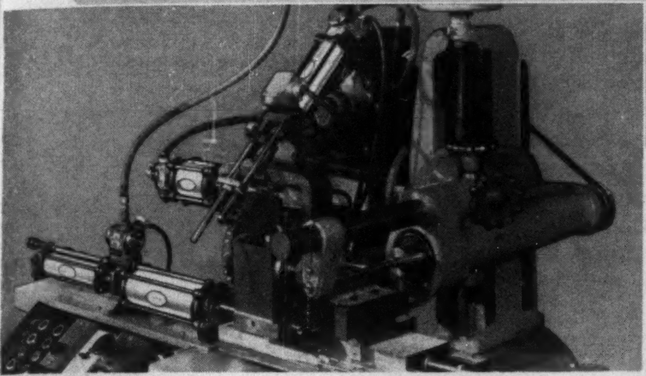
Slide feed for press is operated by air for quiet performance fast setup, and accuracy of feed without shock. Open throat feeds stock of any width, even wire and tubing. Feed operates on standard shop air line pressures and can be made to operate the press effectively.

Machine has positive stock control clamp, single motion gripping action, and self-contained hydraulic cushion, is easily moved from one press to another. **Cooper Weymouth, Inc.,** 277 Noble Ave., Bridgeport 8, Conn.

Circle No. 26 on Reply Card

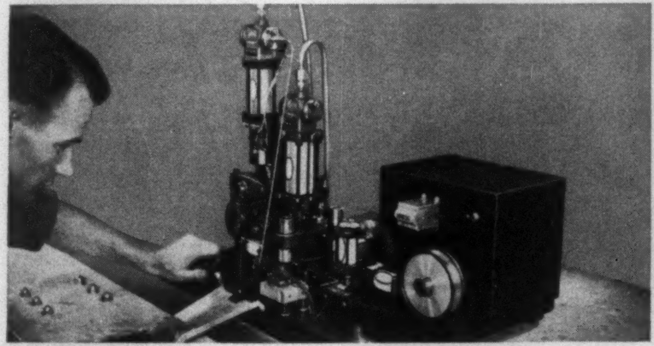
With one or more of these "packaged" power units . .

. . . you can build quickly in your own tool room special purpose, cost saving machines like these:

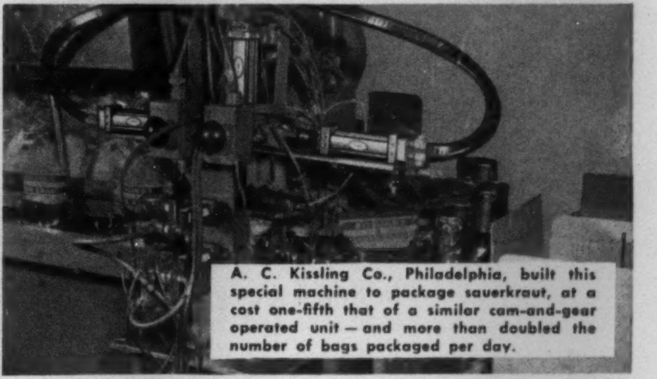


Acetogen Gas Co., Detroit, obtained a 600% production increase in milling splines for their gas cutting torch tips, with this special machine built around Bellows air equipment.

This special testing machine, built around Bellows "Controlled-Air-Power" Devices, increased production from 1,300 parts per day to 3,000 parts per day at the plant of Allis Seal Co., Chicago.



Radio Receptor Co., Inc., Brooklyn, N. Y., designed this tool-room-built cut-off and forming machine and jumped production over the old method by 350%.



A. C. Kissling Co., Philadelphia, built this special machine to package sauerkraut, at a cost one-fifth that of a similar cam-and-gear operated unit — and more than doubled the number of bags packaged per day.

1009A

The next time you get a chance, take a critical look at some of your routine operations — particularly those you've been handling the same way for the past four or five years. There are cost-savings there you shouldn't overlook.

The four illustrations on this page are typical of the ways that Bellows "Controlled-Air-Power" Devices and a little ingenuity can team up to accomplish big savings. It's worth checking into.

WRITE FOR THIS FREE 36 PAGE BOOKLET

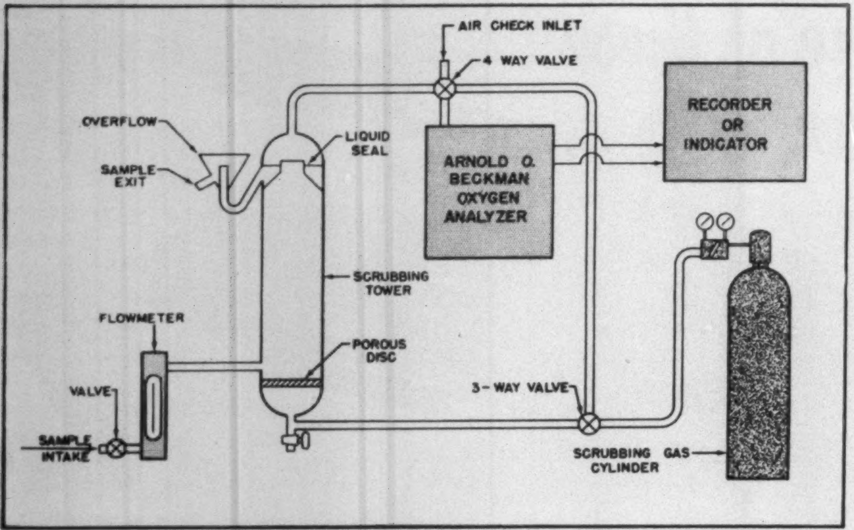
Bellows
DEVICES

Here in these quick-reading pages is the story of "Controlled-Air-Power" — what it is doing for others — what it can do for you. It's free on request. Dept. AU-155. The Bellows Co., Bellows Bldg., Akron 9, Ohio. In Canada, write to: Bellows Pneumatic Devices of Canada, Ltd., Toronto

The Bellows Co.

AKRON 9, OHIO

FIELD ENGINEER OFFICES IN ALL PRINCIPAL CITIES


AIR CHECK INLET
4 WAY VALVE
RECORDER OR INDICATOR
OVERFLOW
LIQUID SEAL
SAMPLE EXIT
ARNOLD O. BECKMAN OXYGEN ANALYZER
SCRUBBING TOWER
FLOWMETER
POROUS DISC
VALVE
3-WAY VALVE
SAMPLE INTAKE
SCRUBBING GAS CYLINDER

DISSOLVED OXYGEN ANALYSIS

Accurate and continuous measurement of dissolved oxygen in waste disposal, sewage and water treatment plants, manufacture of petroleum products, solvents, and chemicals is provided by a new dissolved oxygen analyzer. Unit combines a physical scrubbing mechanism for removing dissolved gases from the liquid being analyzed and a standard oxygen analyzer for measuring the oxygen in the removed gases. Instrument reads per cent saturation directly, but scales, calibrated in parts per million, can be provided. In addition, the analyzer can be used with any standard potentiometer recorder or indicator to simplify installation if specific recorders are required, **Arnold O. Beckman, Inc.,** 1020 Mission St., South Pasadena, Calif.

Circle No. 27 on Reply Card

what article

in this issue would you like

to have in your file?

Just circle the

page number on the reply card

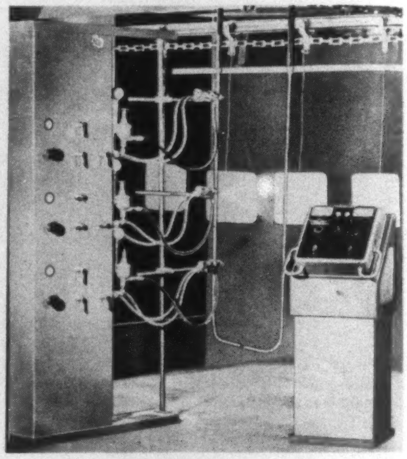
and we'll do the rest.

This service is free. See page 117.

PAINT SPRAY CONTROL

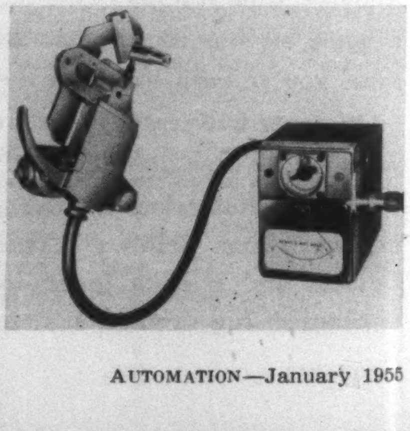
Control of individual paint spray guns is achieved by this flush panel control stand. The control for each spray gun is mounted directly opposite the gun, and the air transformer and timing devices for triggering the guns are housed within the cabinet. Inside tubing is of copper and stainless steel. Maximum finishing economy in such operations as intermittent or skip-spraying is featured with unit's ability to change from model to model instantaneously. **Ashdee Electrostatic Products, Inc.,** 18029 Dixie Highway, Homewood, Ill.

Circle No. 28 on Reply Card



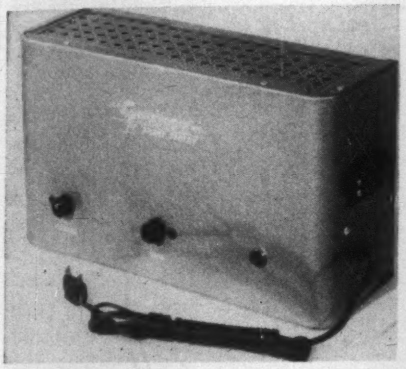
CONTROL GAGE

An electronic micrometer automatically controls a grinding machine's cycle and guarantees tolerances as low as 0.00004-in. This control gage, the size of a shoebox, can be set up on almost any machine in approximately 15 minutes. It withstands rough handling, and is self-compensating for wear, and temperature and moisture changes. Unit is designed to



maintain electronic linearity over a wide range directly translated from the change in mechanical displacement of the gage feeler as it moves with the changing size of the workpiece. Separate models of this gage, with plug-in components, are available for adaptation to different phases in production processes ranging from grinding to sorting. Measuring heads can be supplied for a variety of external or internal cutting, grinding, or other processing requirements. **Electro-Autosizing Machine Div., Industrial Gauges Corp.,** Englewood, N. J.

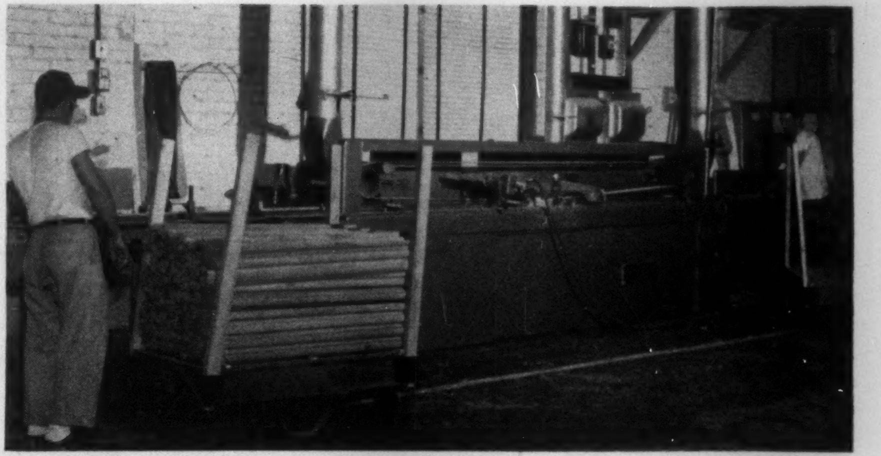
Circle No. **29** *on Reply Card*



SAFETY SHUT-OFF

Operators are protected from injury on all types of automatic machine tools and line assemblies by means of a new safety device called the Silent Sentry. Sentry is equipped with antenna to form a sensitivity pattern about the operating machinery, and stops or changes machine operation immediately if a person moves into the protected area. Antenna can be adjusted so that a body approaching to within 12 in. of the pickup plate will actuate the Sentry. If the power source or any internal part of the Sentry should fail, machinery will stop immediately. Unit operates from a 117 v ac, 50-60 cycle voltage source. Output has both normally open and normally closed contacts so that an external circuit can be used to stop or start machinery. Contacts can handle a noninductive load of 5 amp, 117 v ac. **R. G. Genzlinger, Inc.,** Neshaminy, Pa.

Circle No. **30** *on Reply Card*



AUTOMATIC MOLDING SANDER

Molsander, a new belt sander for sanding molding, features an automatic feed mechanism which can carry work through the machine at rates of 20 to 55 fpm. In addition to a standard sanding head with mounted, formed block, a second head can be added to eliminate returning work for extra passes. Upper and lower feed rolls are covered with rubber tires and driven by a ½-hp motor and by a variable speed drive which is attached to machine's front. Endless belt is rubber covered. Sanding belt is 23 ft long, has maximum width of 9-in., and is powered by a 5-hp motor. Two-speed motor can be provided. Sander will handle work of any usual length, up to 8-in. wide or 8-in. high. Floor space required is approximately 2 x 24 ft. **Bouligny Co.,** 433 W. Morehead, Charlotte, N. C.

Circle No. **31** *on Reply Card*

one source

with years of experience,

proven ability

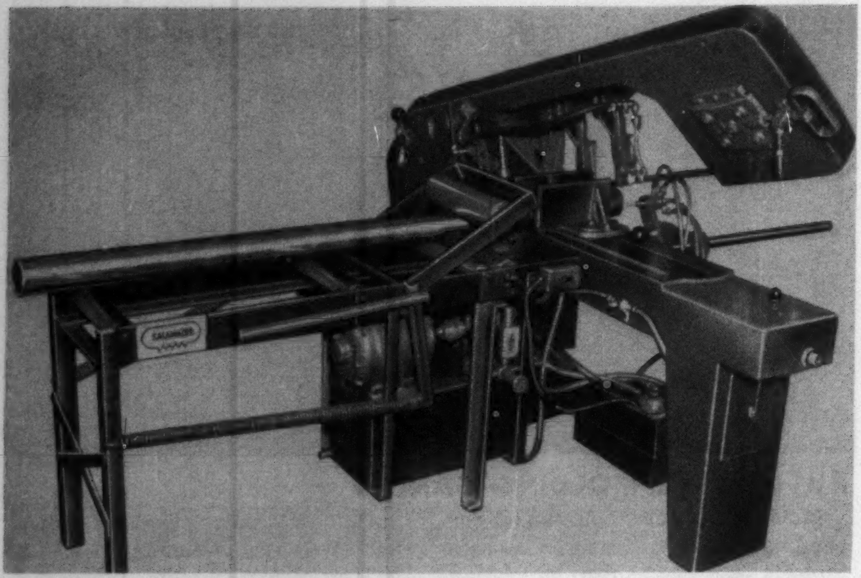
and adequate facilities

to handle your

complete automation program.

serving industry since 1931

Pioneer ENGINEERING & MANUFACTURING CO., INC.
Telephone - TWinbrook 3-4500
19665 JOHN R, DETROIT 3, MICHIGAN

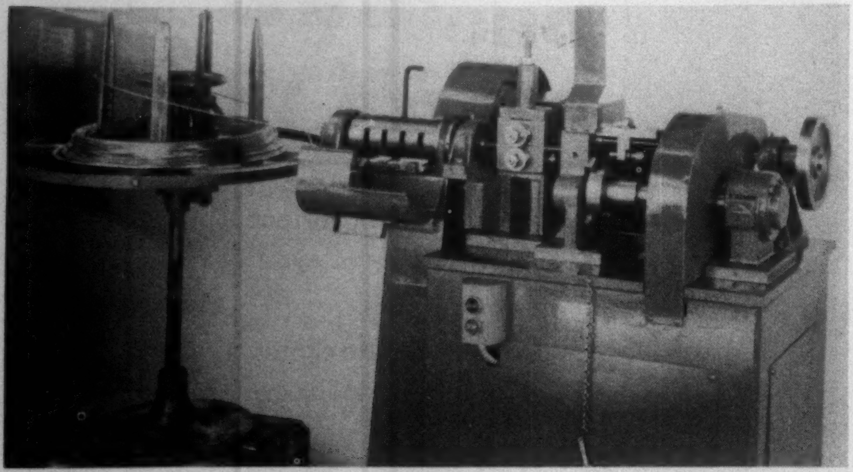


AUTOMATIC BAR FEEDING ATTACHMENT

A new hydraulic unit attaches to most of company's metal cutting band saw machines, converting them into completely automatic bar feeds and metal cutoff saws.

Device opens saw frame to correct height, opens vise, feeds to correct length, clamps vise, and lowers frame at a controlled rate automatically. Standard model feeds lengths from ⅛ to 12 in., and capacity is 6 in. height and 12 in. width. Simple adjustments control height of frame, length of cut, rate of descent of frame, and speed of feed. Relief valve adjusts oil pressure, and a pressure gage and separate switch are featured for the pump motor. **Machine Tool Div., Kalamazoo Tank & Silo Co.,** 500-508 Harrison St., Kalamazoo, Mich.

Circle No. 32 on Reply Card



WIRE PIN MAKING MACHINE

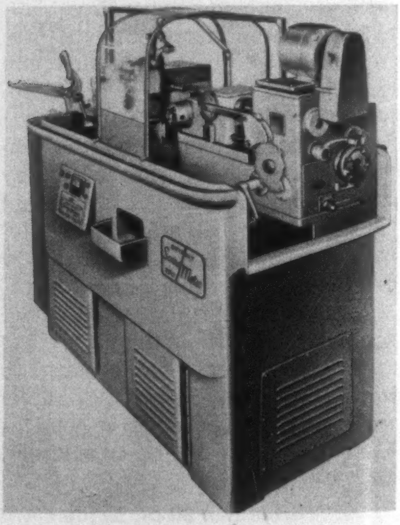
High speed pin-machine cuts pins from wire ⅛ to 3/16-in. diameter in lengths from 7/16 to 4¾-in. at the rate of 18,000 to 75,000 per hour. Finished pins are reported to have ends that require no tumbling to remove burrs. Machine has a straightening arbor which straightens stock as it enters, and a micrometer stop which adjusts for length. Changeover from one size wire pin to another takes only ten minutes. **L. R. Brown Mfg. Co.,** 133C Mill River St., New Haven, Conn.

Circle No. 33 on Reply Card

SCREW MACHINE

Three different spindle speeds can be chosen or adjusted by means of a simple dial setting during actual cutting operation on a new, automatic, single spindle screw machine. Infinitely variable spindle speed drive has replaced gearing, and permits a maximum spindle speed of 5100 rpm (higher speeds available on request). Reversibility of all forward speeds by air pressure eliminates necessity of left-hand tools. A V-belt work drive is used instead of roller chains to drive spindle by means of a clearance spline. Since spindle bearings carry cutting tool pressures only with no drag from drive members or clutch bodies, greater forming precision is assured. The six-station turret is held in precision needle bearings and locked in hardened taper bushings. Tool alignment is further assured by a sub-base slide guide. Standard ¾-in. diameter turret tools are accommodated. Stock is fed by low pressure air cylinders. Machine will take bar stock up to ¾-in. diameter, and turn 2¼-in. stock lengths with a 7-in. cam. Turning lengths up to 6 in. are obtainable with larger cams. The turret slide has a 3-position crank setting, and the turret index drive has three index speeds. These provide turret index strokes of ¼, 1/3, or ½-second turret index time by simple adjustment. Simplified models of the machine are available. **Gear Grinding Machine Co.,** 3901 Christopher, Detroit 11, Mich.

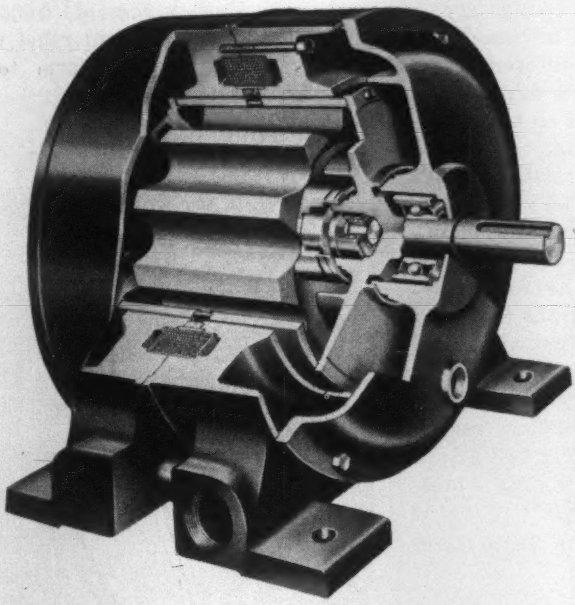
Circle No. 34 on Reply Card



Introducing the New

DYNASPEDE®

Stationary-Field Adjustable Speed
Eddy-Current Coupling



- ★ No brushes, slip rings, or commutator.
- ★ Completely enclosed; adaptable for operation under hazardous conditions.
- ★ Wide-range stepless speed control.
- ★ Reduced maintenance.

Augmenting the well recognized and widely used Dynamatic line of eddy-current couplings, brakes, and drives, the new DYNASPEDE Liquid Cooled Stationary-Field Coupling offers a number of outstanding design and operational advantages.

Principal design features include the mounting of the field section integral with the coupling frame, with the drum-ring rotating concentrically with the field. A toothed rotor (the output member) is mounted concentrically with the drum.

The absence of slip rings and brushes eliminates the possibility of arcing, and adapts DYNASPEDE to hazardous applications in explosive or corrosive atmospheres. Maintenance is materially reduced.

The torque characteristics of the DYNASPEDE coupling are such that with uniform excitation, the torque curve continues to rise with increased slip.

As is the case with all Dynamatic eddy-current couplings, DYNASPEDE provides a very wide range of stepless speed control.

Send for Illustrated Descriptive Literature

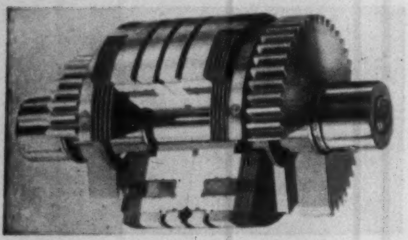
EATON
DYNAMATIC® DIVISION EATON MANUFACTURING COMPANY
KENOSHA, WISCONSIN • General Offices: Cleveland, Ohio

R

AUTOMATION

NEW COMPONENTS

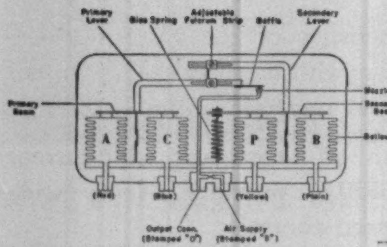
Parts, elements and devices designed for creating more automatic systems



Electromagnetic Clutch

A new electromagnetic clutch for machine tool and automatic transmission applications is particularly suitable to those operations requiring constant mesh gearing. Constant horsepower output, quiet operation, and rapid speed change are provided. Clutch is controlled by a 24 v dc circuit, and no field adjustment of the torque value of the unit can be made. Since the clutch is self compensating, no adjustment for wear of the clutch plates is necessary. **Rectifier Div., I-T-E Circuit Breaker Co.,** 19th & Hamilton Sts., Philadelphia, Pa.

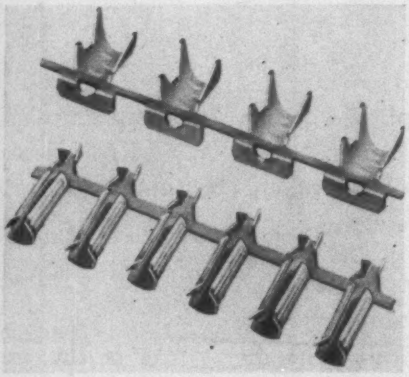
Circle No. 35 on Reply Card



Computing Relay

A pneumatic force-balance transmitter with output linear to any input pressure changes, this new Transet computing relay is capable of adding, subtracting, averaging, and ratioing in computing applications. Accuracy is ½-per cent. Instrument is suitable to processes where two or three different signals must be compared, and where variables are required to maintain a constant relationship to each other. Instrument consists of four receiver bellows, a fixed nozzle, and a movable baffle. System of fixed and adjustable levers mechanically connects the force-balance bellows and positions the baffle as a function of input air pressure and lever adjustment. Simple setting of fulcrum strip in ratioing applications accommodates range of adjustments from 7:1 to 0.33:1. **Taylor Instrument Cos.,** 95 Ames St., Rochester 1, N. Y.

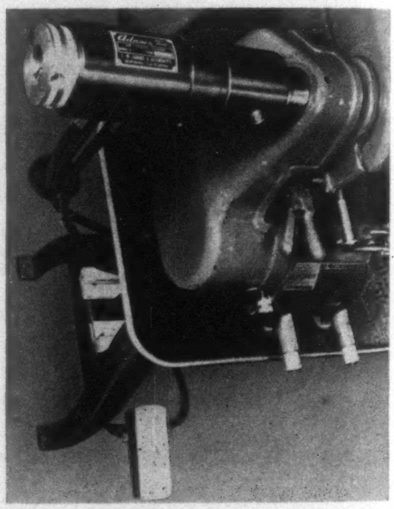
Circle No. 36 on Reply Card



Strip Form Heater Cord Parts

Components of heater cord assemblies are produced in strip form for quick, automatic attachment. Female connectors in strip form provide fast, automatic dual attachment, excellent pull test, and close contact throughout entire length of barrel to prevent arcing. They are made of copperclad steel with resistance of 0.0042 ohms at 10 amp. Strain relief is also available in strip form for quick automatic single attachment. **Electric Terminal Corp.,** Dept. H, 75 Virginia Ave., Providence 5, R. I.

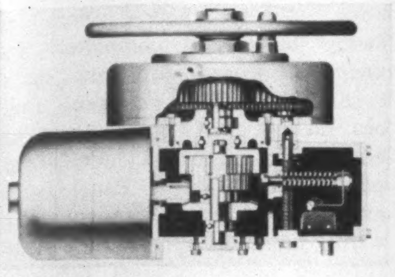
Circle No. 37 on Reply Card



Collet Closer

Air operated collet closer insures fast, positive power opening and closing of 1⅜-in. or smaller hollow spindle lathes using internal or external collets and with maximum 1-in. bar stock capacity. Spindle speed can be as high as 4500 rpm. An air operating piston works on a cam and dog action in the closer, and simple hand adjustment can change draw-bar pull instantly from 0 to 5000 lb with no change in actual air pressure. After 2 million strokes during an eight month period no measurable wear on mechanical parts or packing was reported. **I. W. Adams & Associates,** 4200 Burbank Blvd., Burbank, Calif.

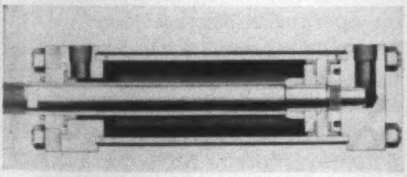
Circle No. **38** *on Reply Card*



Valve Operating Unit

Electric valve operators can be used with all conventional gate, globe, plug and butterfly valves in sizes from 2½-in. up, and provide a wide range of operating speeds, output torque, and length of travel. Installation on valves in or out of service is simple and requires no alteration of the valve. Operating unit, known as Tork-Master, is a means of operating valves through electrical control systems, may be timed to function automatically with other equipment. Power cuts off instantaneously when proper seating of valve has been attained. Stem thrust can be regulated to any predetermined value in either direction. Tork-Master is available in three sizes with ¼ to 3 hp motors. **McBain Corp., Harvill Corp.,** 6251 West Century Blvd., Los Angeles 45, Calif.

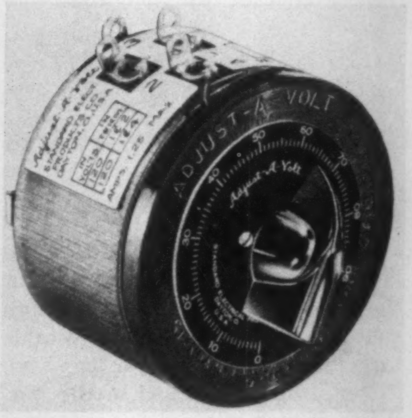
Circle No. **39** *on Reply Card*



Hydraulic Cylinder

Use of square rod end and head end caps to house pipe connections minimizes installation space requirements for a line of hydraulic cylinders applicable to machine tool, metalworking, and general industrial use. Mounting flexibility is achieved by multiple positioning of ports and air vents. Five available mountings are foot (bracket), flange (head end), flange (rod end), extended tie rod, and clevis. Maximum working pressure is 2000 psi. Cylinders are furnished with 1½ to 6-in. bore sizes, and with standard or heavy duty piston rods. Heavy rod is for applications involving differential operation with approximately equal speeds in both directions, requiring extra stiffness or faster return stroke. "O"-ring gasket type construction is used in assembly of barrel, end caps, and piston rod bushing for positive seal. Impregnated leather piston cup seals are used for long life and low friction at oil temperatures up to 165°F. **Waterbury Tool Div., Vickers Inc.,** 1400 Oakman Blvd., Detroit 32, Mich.

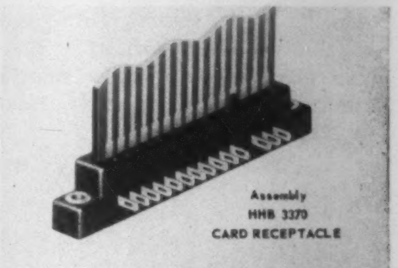
Circle No. **40** *on Reply Card*

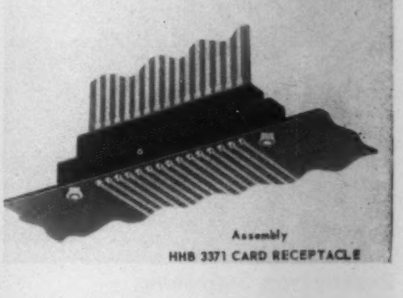


Variable Transformer

Adjust-A-Volt variable transformer is installed easily in the back of a panel for low wattage applications of 50, 100, and 150 w loads. Transformer is rated single-phase, 60-cycle, with 120 v input and 0 to 120 v output, 1.25 amp output, 150/165 va. Basically the unit is a toroidally wound, hydrogen annealed auto-transformer which continuously delivers any output voltage from zero to above line voltage. Voltage adjusts with no waveform distortion. An extra long brush spring allows free action and maintains constant brush pressure during entire brush life. A safety stop on the spring prevents burnouts by making it impossible for brush holder to contact the winding when the brush has completely worn down. Alloy brush track plating eliminates deterioration of the commutation surface and assures longer life. **Standard Electrical Products Co.,** 2240 E. Third St., Dayton, Ohio.

Circle No. **41** *on Reply Card*

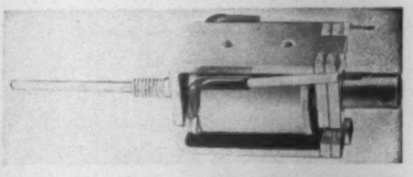




Circuit Card Receptacles

New printed card receptacles come in two series with as many as 15 contacts. Enclosed contact tips and positive pressure-type contacts are combined for quality operation. Contacts are of beryllium copper plated with gold over silver. In series 3370 the wire connector tabs can extend from right, left, or bottom, or in combination, while in series 3371 terminals are at bottom only for card thicknesses of 1/16, ⅛, and ¼-in. Mounting is via quick solder dip assembly, and nominal creep is 3/32-in. Connectors come in green mineral filled phenolic, in diallyl phthalate MDG, or general purpose phenolic CFG. **H. H. Buggie, Inc.,** 726 Stanton St., Toledo 4, Ohio.

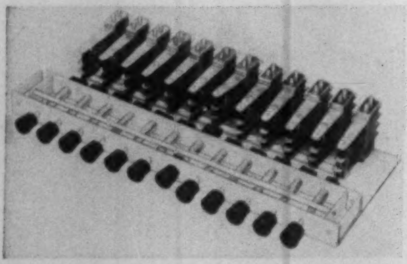
Circle No. **42** *on Reply Card*



Custom Solenoids Standardized

Three hundred different dc solenoids can be assembled from 20 standard parts to meet custom requirements without sacrificing economy, interchangeability or speed in delivery. Two series, 100 and 300 dc, are available. Units may be changed quickly to push or pull types by simply adding a threaded 3/32-in. diameter push rod to any plunger. Solenoids are compact and lightweight, and available with a variety of mountings, coils, and wire sizes. **Joseph Pollak Corp.**, 81 Freeport St., Boston 22, Mass.

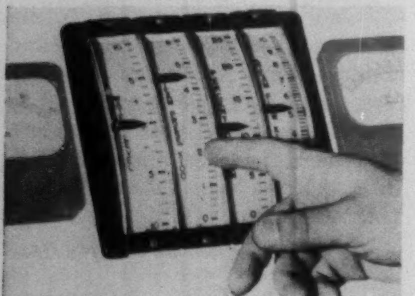
Circle No. **43** *on Reply Card*



Pushbutton Switching

Easily mounted, redesigned pushbutton switches offer centralized control of a number of circuits. Pushbuttons are mounted on a sturdy, extruded frame in units of from two to a maximum of twelve positions. Switching units may be accumulative lock, no two interlock, lock release, and nonlock types. **General Control Co.**, Boston 34, Mass.

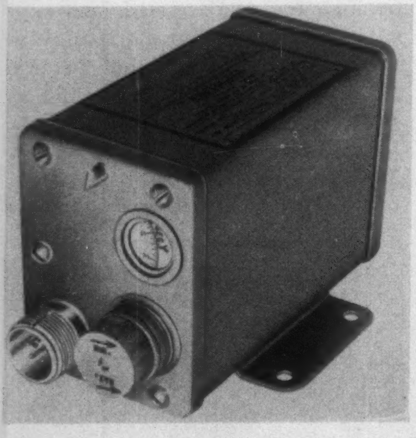
Circle No. **44** *on Reply Card*



Remote Indicator

Easily legible, miniature remote indicator is available as either electric or pneumatic receiver to measure pressure, draft, flow, level, or temperature. Scale units are removable, zero adjustment is simple, illumination is internal, panel mounting can be flush or semiflush, with no parallax. Gage can be supplied with two units in a single case and two pointers on the single 5-in. scale. A spring-loaded metallic bellows with built-in overpressure protection is the actuating element for the pneumatic gage. Electric model consists of a special motor, electronic amplifier, and a pair of differential transformers which form an electric null balance circuit. **Hays Corp.**, Michigan City, Ind.

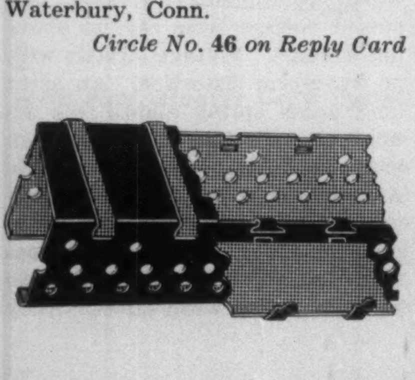
Circle No. **45** *on Reply Card*



Sealed Time Delay Relay

New, hermetically sealed time delay relay permits adjustment of the time delay period through coupling of a standard adjustable type unit to a hermetic rotary seal. Timer, totally enclosed in the hermetic housing, can be adjusted after sealing with a convenient knurled knob. Time delay period can be from 2 seconds to 2 hours. Calibrated dial is read through a glass window, allows settings to be varied over an 8:1 range in small increments. Relay can be supplied to operate on dc or ac power supply, with bracket or stud mounting. One or more switches can be used, and electrical connection can be via AN connector or a glass-metal header. **A. W. Haydon Co.**, Waterbury, Conn.

Circle No. **46** *on Reply Card*



Cover Clips for Wiring Duct

New safety cover clips designed for use with company's Panel-Chanel plastic wiring duct make it impossible for metal to loosen and foul controls. Clips are inserted through slots in sides of channel and covers are fitted to clips. Clips allow covers to swing back and completely expose all wiring for easy maintenance or wiring changes. Covers do not have to be removed nor wires unlaced. Perforated plastic sides of the Panel-Chanel are fastened to the control panel, wiring is laid in duct and pulled through proper leadoff holes for connection to electrical components. **Stahlin Bros. Fibre Works, Inc.**, Belding, Mich.

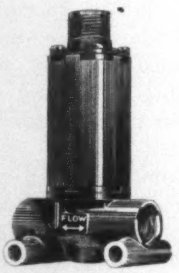
Circle No. **47** *on Reply Card*

PRATT & WHITNEY

Material Thickness Control

A new mill control unit provides automatic correction of thickness variations in materials being rolled. The control unit is mounted at any convenient location on the mill, and the indicating meter is located on operator's control panel. Control can be used with any continuous mill gage and with any electrically operated screwdown motor. Desired tolerances are set by potentiometers. As soon as gage registers undersize or oversize, the control unit releases an electrical impulse to the screwdown motor or a similar control mechanism on the mill. This control motor operates intermittently, allowing a time delay between each period for the correction to reach the gage. Duration of correction is progressive; i.e., the further away from zero, the longer the duration of adjustment. Incorporated safety devices will automatically shut down the unit in case of tube failure, mill stoppage or slowdown below a predetermined rpm, or correction process taking too long to effect. **Pratt & Whitney, Div., Niles-Bement-Pond Co.,** West Hartford 1, Conn.

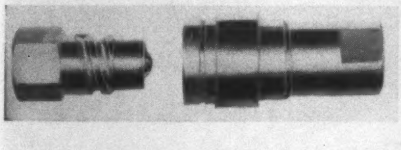
Circle No. 48 *on Reply Card*



Solenoid Valve

Solenoid valve is extremely lightweight in relation to flow capacity. Unit operates on 18 to 30 v dc, with a current drain of ½ amp at 24 v dc, and has a maximum operating pressure of 100 psi. Flow is straight-through with an absolute minimum pressure drop. Valve is self-lapping and self-cleaning, has floating gate-type seal. Solenoid coil is shock, vibration, and weather resistant. Ports are available normally open or normally closed. **Valcor Engineering Corp.,** Carnegie Ave., Kenilworth, N. J.

Circle No. 49 *on Reply Card*



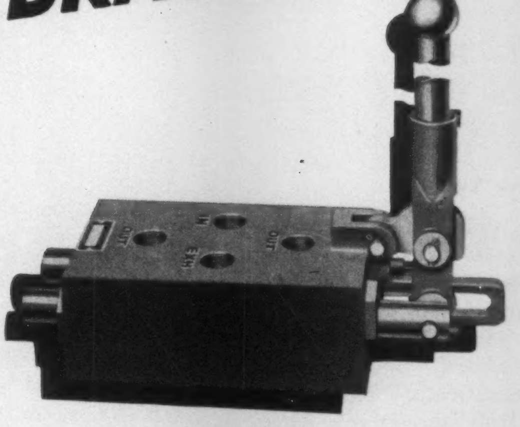
Fast, Positive Coupler

Quick disconnect and breakaway coupler for hydraulic and air lines can be coupled or uncoupled under pressure without tools and will not lose any pressure or fluid. Known as the "Jiffy", the coupler features ball check valve construction and positive sealing action. When it is uncoupled, both lines are instantly sealed. "Jiffy" is made of plated, rust-proofed steel and has tempered valve seats, will withstand pressure up to 10,000 lb. Sizes are from ⅜ to 1 in. **Standard Valve & Coupler Co.,** 1114 Ulysses Ave., N.E., Minneapolis, Minn.

Circle No. 50 *on Reply Card*

Quick-As-Wink®

HYDRAULIC VALVES

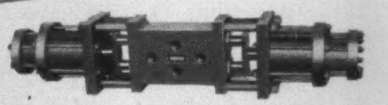


Hand Lever and Pilot Cylinder Types—pressures to 5000 psi.

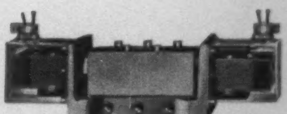
Have won industry wide recognition for unsurpassed dependability

○ Positive and fast acting, Quick-As-Wink Control Valves are designed and built to meet the most exacting requirements. Bodies of hydraulic valves are either forged or milled from solid bars. The hollow, radially ported, stainless steel plungers are chrome plated and polished to minimize wear. All parts are readily accessible and maintenance—that consists mostly of the very occasional replacement of the packing — can be done easily **in the field** without even disconnecting the piping. This avoids the necessity of returning valves to the factory for servicing or maintaining large standby inventories. Let us recommend the sizes and types that will meet your requirements best. Write for Bulletin 531. It gives full details.

Ask us also about...



DOUBLE PILOT CYLINDER HYDRAULIC VALVES operated with air or hydraulic pilot cylinders—3 position; neutral, compound-on or compound-exhaust.



DOUBLE SOLENOID "O-TYPE" VALVES for pressures up to 125 psi. Widely used as pilot valves and for operating air cylinders.

Quick-As-Wink
AIR AND HYDRAULIC
Control Valves

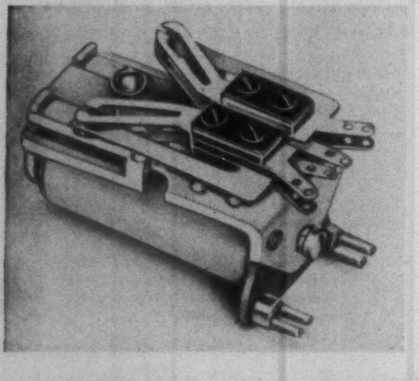
Hand, Foot, Cam, Pilot, Diaphragm and Solenoid Operated

Mfd. by C. B. HUNT & SON, INC., 2075 East Pershing St., Salem, Ohio

24-Hour Time Switch

A 24-hour time switch incorporates trip levers scaled in 15-minute graduations on dial face which permit easy setting of as many as 48 "on" and 48 "off" operations in any 24-hour period. Settings will repeat automatically until rescheduled. Unit is available with or without a special calender device which cuts out non-working days. Heavy duty, self-starting, self-lubricating, synchronous industrial motor powers the single pole, double throw switch. Capacity is 1000 w, 60-cycle ac. Switch is applicable to heating, ventilating, and air conditioning systems, and to oil and gas burners. **Dept. ANC, Zenith Electric Co.,** 152 W. Walton St., Chicago 10, Ill.

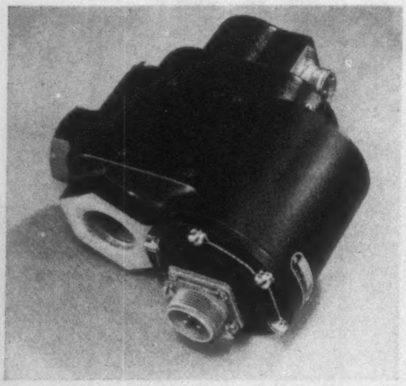
Circle No. 51 on Reply Card



Relay with Twin Contacts

Bifurcated (twin) contacts developed for relays permit reliable switching of extremely low voltage and low current. Flexibility of the long contact springs enables twin points to make contact independently, i.e. one point can make contact while the other is blocked by dust or grit. Contacts are available for ac or dc Series 22 relays, in open models and in a wide selection of hermetically sealed, dust-tight enclosures. **Magnecraft Electric Co.,** 1442-V W. Van Buren St., Chicago 7, Ill.

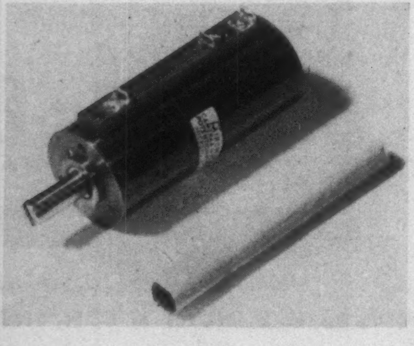
Circle No. 52 on Reply Card



Flexibelt Control Valve

New valve employing flexible belt to control flow is ideally suited to any control system where speed of operation and error signal for stable control must be proportional. In high speed aircraft it will provide remote control of fuel flow, or it will control gas temperature by variation of flow to turbojet engine. A 10 w servo motor operates the valve in an ignition-proof housing. Valve contains a flexible belt mounted over slotted port on the high pressure side. When belt covers entire port and is held fast by pressure, flow is cut off. Flow becomes proportional to exposed space as belt rolls away from port. **Manning, Maxwell, and Moore, Inc.,** 1943 Elias St., Bridgeport 2, Conn.

Circle No. 53 on Reply Card



10-Turn Potentiometer

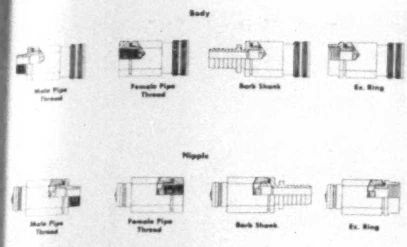
Small size, high mechanical rigidity, and electrical stability are combined in a new 10-turn potentiometer. Unit is 1-in. in diameter, 2½-in. long, has ¼-in. diameter shaft, and 26½-in. of coil length. Guaranteed accuracy is ±0.25 per cent in the standard resistance range of 4000 to 200,000 ohms, ±0.1 per cent in special applications. Standard three-hole, servo, and threaded bushing mountings are available. Starting torque of 1 oz-in. and running torque of ½-oz-in. make possible the use of small servomotors with low power, thus reducing size requirements of this type of servomechanism equipment. **Potentiometer Div., Fairchild Camera & Instrument Corp.,** 225 Park Ave., Hicksville, L. I., N. Y.

Circle No. 54 on Reply Card

Timer and Cycle Control

Automatic timer and cycle controller governs any electrical machine operating on cycle and eliminates necessity for additional relays. It can be used for timed quantity measurements in production processing of liquids or solids, for operation of coin-operated vending machines, and for sequential production operation. Delivery of articles or materials is prevented as long as a normally pulsed circuit is continuously closed. Operation cycle can be set to meet any requirements. **Johnson Fare Box Co., Bowser, Inc.,** 4619 N. Ravenswood Ave., Chicago 40, Ill.

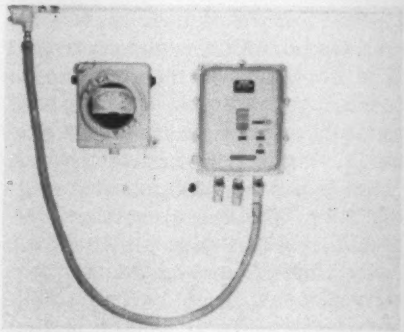
Circle No. 55 on Reply Card



Quick-Seal Hose Couplings

Single or double check valves are built into a new line of quick-seal, leak-proof hose couplings for high pressure, heavy flow fluid lines. The higher the pressure builds up inside the coupling, the tighter the seal becomes. A full-swiveling feature prevents hose kinking. Coupling shuts closed either one end or both ends of the fluid line as soon as coupling is opened. Check valves are automatically opened, permitting full fluid flow, as soon as coupling is closed. Check valve eliminates need to shut down pumps or close valves in order to break the connection, prevents loss of fluid when line is opened, and eliminates need to drain lines prior to uncoupling. Couplings are available in cadmium plated steel, aluminum, brass, stainless steel, and alloys. **Titeflex, Inc.,** 500 Frelinghuysen Ave., Newark 5, N. J.

Circle No. **56** *on Reply Card*



Electronic Level Indicators

Explosion proof cases have been designed for a line of continuous level indicators which meet requirements for flammable gases or vapors (ethyl ether vapor, gasoline, naphtha, alcohols, lacquer, natural gas, etc.) and combustible dusts (metal dust, carbon black, coal or coke dust, and grain dust). Indicators, called Telstors, are basically one-tube, electronic, standard level indicators for measuring mass or level of liquids, viscous fluids, powders and granular solids, whether conducting or non-conducting. No moving parts are present to clog or cause inaccuracies. Indicators are available in several combinations to meet many industrial and laboratory applications. **Fielden Instrument Div., Robertshaw-Fulton Controls Co.,** 2920 N. Fourth St., Philadelphia 33, Pa.

Circle No. **57** *on Reply Card*

Electronic Industrial Counter

Electronic totalizer counts pulse or sine wave signals of 10 mv or greater at frequencies up to 1000 cps. Improved circuitry due to glow-transfer decade counting tubes makes possible economical consumption of space and power. Counter can be mounted in a standard relay rack, uses only five thermionic tubes and draws 22 w of 95-135 v 50-60 cycle ac. Two

Through-Feed Cylindrical Work on
NEW FEEDALL TRANSFER CONVEYORS!

Cylindrical work for centerless grinders, special polishing and inspection machines is through-fed on this machine. In fact, the unit is adapted to a variety of industrial equipment.

The entire unit is self-contained. The drive mechanism is powered with a ¼ H.P. 220/440 Volt, 3-phase motor. Feed rate is controlled by means of a variable speed drive and a range of 7 to 28 feet per minute is available on the standard unit. Standard unit is 60" long—is designed for work range of ¼" to 1½" diameter. Other models are available for other diameters and lengths.

Send us your specifications for our suggestions and quotation.

The Line of FEEDALL Automatic Feeders includes machines with Hopper, Blade, Vibratory and Rotary Feeds.

Let us give you information on the proper types for your needs.

FEEDALL
MACHINE AND ENGINEERING CO.
WILLOUGHBY, OHIO, U.S.A.

TRANSISTOR &
DIGITAL COMPUTER
TECHNIQUES

applied to the design, development and application of

AUTOMATIC RADAR DATA
PROCESSING, TRANSMISSION
AND CORRELATION IN
LARGE GROUND NETWORKS

ENGINEERS
&
PHYSICISTS

Digital computers similar to the successful Hughes airborne fire control computers are being applied by the Ground Systems Department to the information processing and computing functions of large ground radar weapons control systems.

The application of digital and transistor techniques to the problems of large ground radar networks has created new positions at all levels in the Ground Systems Department. Engineers and physicists with experience in the fields listed, or with exceptional ability, are invited to consider joining us.

fields include

TRANSISTOR CIRCUITS
DIGITAL COMPUTING NETS
MAGNETIC DRUM AND CORE MEMORY
LOGICAL DESIGN
PROGRAMMING

VERY HIGH POWER MODULATORS
AND TRANSMITTERS

INPUT AND OUTPUT DEVICES
SPECIAL DISPLAYS
MICROWAVE CIRCUITS

Scientific and Engineering Staff

HUGHES

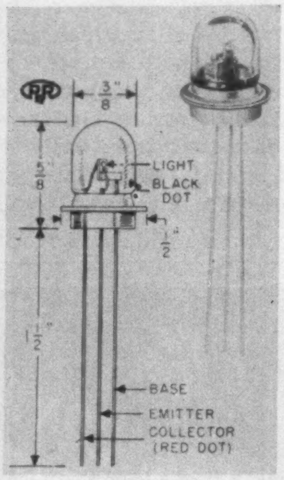
RESEARCH AND
DEVELOPMENT LABORATORIES

Culver City, Los Angeles County, California

Relocation of applicant must not cause
disruption of an urgent military project.

decade counting tubes are used with a six-digit mechanical register to give counting capacity of 99,999,999. Tubes are rated at 10,000 hours. Remote start-stop connection in addition to manual switch on instrument panel facilitates counting over controlled time intervals. Instrument can be started and stopped by means of an external electric timer for precise timing of periods during which count is taken. Each decade-counting tube with one associated electronic tube replaces ten neon bulbs and four electronic tubes conventionally employed in counting circuits. Total weight is four lb. **Potter Aeronautical Co.,** Route #22, Union, N. J.

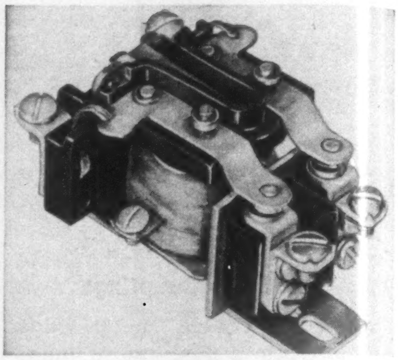
Circle No. **58** *on Reply Card*



Miniature Photo Transistor

Intended for a variety of industrial control applications, a miniature photo transistor consists of a light sensitive element hermetically sealed within a glass bulb and connected to three leads emerging from a glass header. Diameter of glass bulb is ⅜-in. and overall height is ⅝-in. Base connection is available for thermal stabilization in modulated light applications. Spectral response extends merizing type varnish, resistant to moisture and acid, is used on the beyond the visible range into the infra-red for black light applications. **Seletron & Germanium Div. Sales Office, Radio Receptor Co.,** 251 West 19th St., New York 11, N. Y.

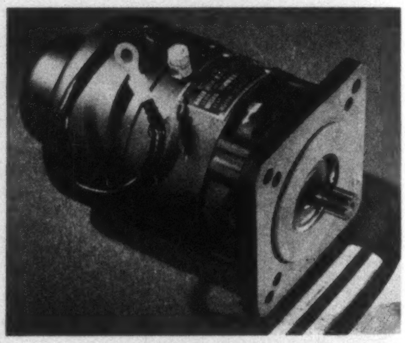
Circle No. **59** *on Reply Card*



Circuit Control Relay

Heavy duty circuit control relays for electrical and electronic commercial and industrial applications will handle heavy contact loads with low coil power requirements. Compact, lightweight and rugged, relays can be mounted from above or below mounting surface as desired. Units are rated 20 to 15 amp resistive and inductive, ½-hp at 115 to 230 v ac. Coils operate on 6 to 230 v ac, 60 cycles, continuous duty, 8.5 va, or on 6 to 230 v dc, continuous duty, 4.4 w. Maximum coil voltage is 600 v ac and 230 v dc. Dimensions are 3 x 1⅞ x 1 15/16-in. **Leach Relay Co.,** 5915 Avalon Blvd., Los Angeles 3, Calif.

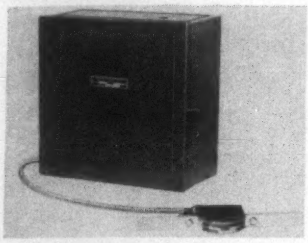
Circle No. **60** *on Reply Card*



Speed Regulated Motor

A continuous duty motor produces 1 hp at 12,000 rpm, regulated to ±6 per cent in speed variation, and provides a high starting torque of 110 lb-in. Motor draws 45 amp, operates in a range of 25 to 29.5 v dc, regulates over a load variation of 2/3 to 1 hp. Its resistance to adverse temperature, humidity, and pressure conditions suit unit to many high-torque, speed-regulated driving applications. Bypass capacitors are incorporated at the armature and governor brushes for minimum radio interference. Shielded positive lead and a grounded negative stud form input connections. Illustrated motor has a geared output shaft, but plain shafts can be furnished in any required length. Splines, keyways, and similar arrangements are also available. **Dalmotor Co.,** 1304 Clay St., Santa Clara, Calif.

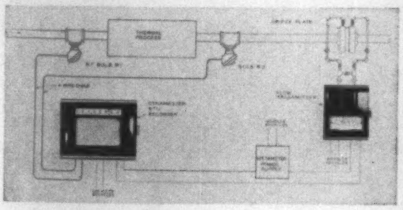
Circle No. 61 *on Reply Card*



Impact Actuated Controls

Electronic controls for operating die protection mechanisms, work stoppage signals, and counters are impact actuated. An impact-sensitive pickup connects to an electronic amplifier and relay by a plastic coated cable. Impact of 1/10-oz falling 2-in. against impact pickup operates control. Pickup may be attached to larger plate or to a chute. When operated by very small objects, pickup can be equipped with anti-vibration mounting bracket assembly. Amplifier is adjustable to varying impact intensities. **Autotron Co.,** Box 722-RR, Danville, Ill.

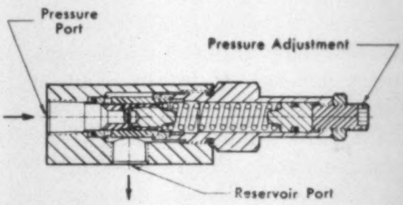
Circle No. 62 *on Reply Card*



Heat Controller and Recorder

Dynamaster BTU recorder-controller system continuously measures and controls rate of heat input or output in process vessels, refrigerating plants, air conditioners, and other heat exchanging devices. Additional apparatus is available to regulate temperature or flow rate of the heat transfer medium. Basic BTU recording system consists of one Dynamaster measuring temperature difference with two resistance thermometer bulbs, receiving flow rate from a flow transmitter and continuously computing and recording the BTU product of the two variables. Matched resistance bulbs are not required as an optional bulb trimming adjustment can be supplied whereby replacement bulbs can be installed and matched to the system by trimming. **Bristol Co.,** Waterbury 20, Conn.

Circle No. 63 *on Reply Card*



Relief Valve

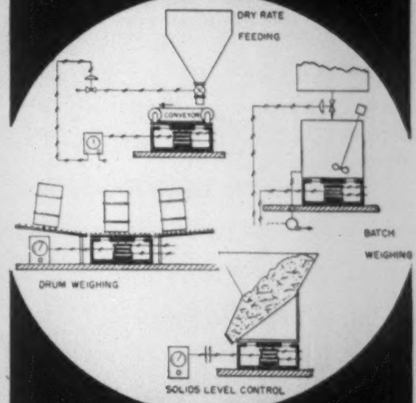
A spring loaded, guided piston type relief valve controls pressure in clamping or feed circuits, and is particularly applicable to circuits where pressure is controlled by a continuous flow through the relief valves. Parts are of hardened steel, ground or honed to fine finish and close tolerance. Valve features fast response and quiet operation, can be furnished in ¼ or ⅜-in. sizes. Seven available pressure ranges extend from 10-30 psi to 200-600 psi. Standard, screw, or hand knob pressure adjustments are supplied. **Fluid Controls, Inc.,** 1284 N. Center St., Mentor, Ohio.

Circle No. 64 *on Reply Card*

Phase Sequence Indicators

Phase sequence indicator also functions as pilot light in specially designed units for three-phase equipment, insuring proper rotation of blowers and motors without further checking. An electrical

a NEW tool for process control



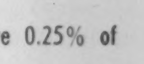
W/C Weighing Scale
PNEUMATIC-PLATFORM TYPE

- For batch or continuous weighing of solids or liquids
- For remote indication or continuous flow control
- With accuracy above 0.25% of range
- Highly sensitive, extremely rugged
- No springs, knife edges, or levers
- Unaffected by off-center loading on platform
- Unaffected by vibration

Here's the latest step toward continuous process control of your plant—especially in explosive or dusty atmospheres. It's the new W/C Weighing Scale . . . fully tested, proved, and guaranteed to cut processing time or improve your yield.

Based on the force-balance principle, the W/C Weighing Scale translates weight into a pneumatic output signal. It is furnished complete with a remote panel containing a weight indicating scale 45 inches long.

Available in ranges up to 5000 pounds, it is the first device that reliably uses weight as a criterion of measurement to meet the demands of modern process control.

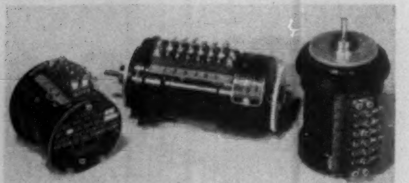


WRITE FOR Catalog which gives complete details, engineering drawings, and calibration curves.

WEIGHING COMPONENTS, INC.
"64-A Fulmor Ave. • Hatboro, Pa."

network senses the phase rotation and provides voltage greater or less than voltage required to light a neon indicator which indicates proper phase rotation. Connection to unit is made through a standard three pin plug. Two models are available for 60 or 400 cycles per second operation, and each model is available for 110, 220 or 440 volt operation with standard or dimmer type lenses. Adapter units can convert existing pilot light assemblies into phase sequence indicators. **Brunswick Instruments,** 66 Wendmere Rd., New Brunswick, N. J.

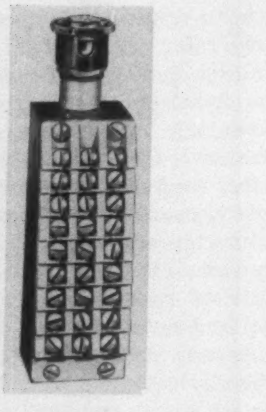
Circle No. 65 on Reply Card



Magnetic Clutches and Brake

Miniature line of magnetic clutching and braking devices includes a single clutch, a double clutch, and a clutch brake for application in computers and mechanisms requiring extreme accuracy. Units provide continuous operation, immediate release upon de-energizing, rapid pull-in, negligible steady state control current requirement, wide environmental range, compactness, and light weight. Dragging on friction face is precluded because units are designed with a definite neutral position for the friction disc. Anodized finish, fungus-inert materials, and capsulated windings meet military environmental specifications. Operating temperature range is −65 to 165° F. When a telephone type relay is added, the maximum response time of the three units is six milliseconds or less, whereas it is slightly higher without a relay. Designed for a maximum torque of 16 oz-in., brake and clutches operate intermittently at speeds up to 1000 rpm. Life expectancy is at least 20,000 cycles at 30 rpm with a load inertia of 1 oz-in. Available from **Ford Instrument Co., Sperry Corp.,** 31-10 Thomson Ave., Long Island City 1,

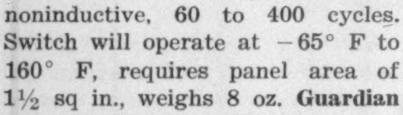
Circle No. 66 on Reply Card



8-Pole Double-Throw Switch

An 8-pole, double-throw switch will instantly switch or disconnect eight primary circuits. It may stop or start machines, shut off boiler feeds, dump fuel, or start extinguishers. Maintaining a constant contact pressure of 4 oz per point throughout the stroke until positive action occurs in either direction, switch has no dead center. Contacts handle 5 amp, 28 v dc inductive, or 10 amp, 115 v ac noninductive, 60 to 400 cycles. Switch will operate at −65° F to 160° F, requires panel area of 1½ sq in., weighs 8 oz. **Guardian Electric Mfg. Co.,** 1621 West Walnut St., Chicago 12, Ill.

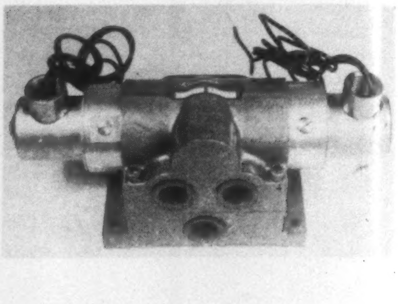
Circle No. 67 on Reply Card



Vibration Sensitive Control

Inexpensive control instrument actuates warning or shuts down automatic or infrequently attended machinery in case of any malfunction causing an increase in vibration. It can be used also for vibration measurements. Flat response of 0 to 200 cps, with decreasing sensitivity up to 500 cps, permits unit's use on most rotating or vibrating equipment including compressors, machine tools, and engines. Vibraswitch consists of an acceleration sensitive actuator and an internal, single pole, double throw, manually resettable switch which may be used to control circuits at as much as 5 amp with vibratory displacement increases of as little as 10 mu in. at 12,000 rpm. Maximum range is 2 g, or approximately 800 cps squared. **Beta Corp.,** Box 8625, Richmond 26, Va.

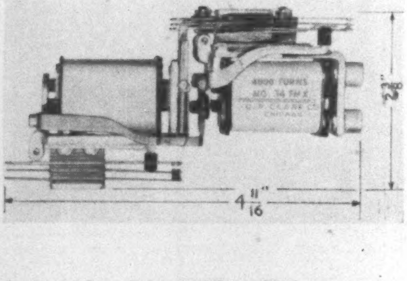
Circle No. 68 on Reply Card



Control Valve

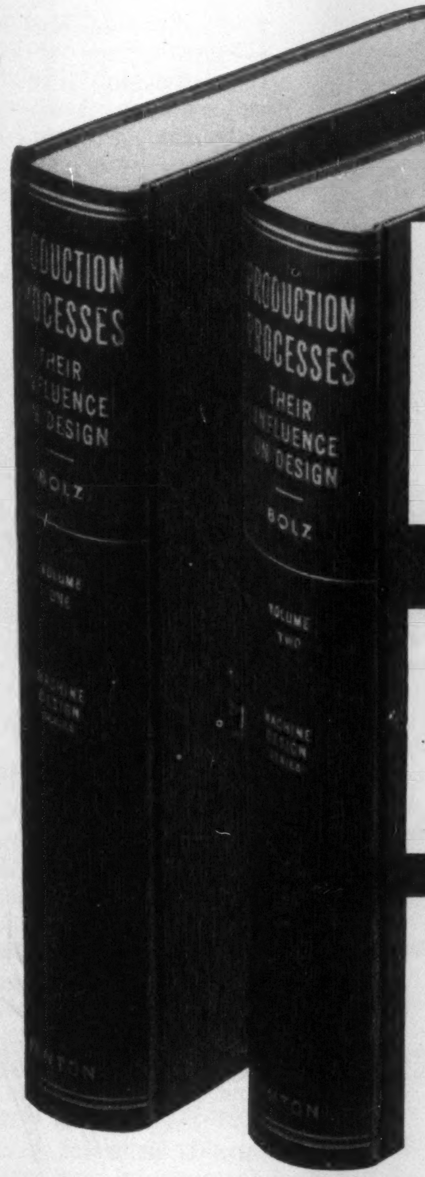
Only moving part in a new 4-way valve is the one-piece spool carrying standard "O" ring moving seals. Valve is designed for air or hydraulic service up to 200 psi. It is adaptable to sub-base, manifold, panel, console, or conventional piped installations. Operation can be via lever, palm button, foot pedal, treadle roller, cam, solenoid, pilot, or remote bleeder button. All parts are standardized and interchangeable so that almost any type valve may be assembled or repaired from a minimum stock of basic parts. Two models accommodate ⅜ and ½-in. NPT ports, or ¾ and 1-in. NPT ports. Body is cast aluminum, liner is hard-drawn brass, spool is aluminum. **Modernair Corp.,** 400 Preda St., San Leandro, Calif.

Circle No. 69 on Reply Card



Long Lived Latching Relay

An electromechanical relay, originally designed to meet service requirements of a business machine manufacturer, has life expectancy of millions of operations. Illustrated assembly consists of two ac relays with interlocking armatures aligned one above the other on a


PRODUCTION PROCESSES THEIR INFLUENCE ON DESIGN
BOLZ
VOLUME ONE
MACHINE DESIGN SERIES
PENTON
PRODUCTION PROCESSES THEIR INFLUENCE ON DESIGN
BOLZ
VOLUME TWO
MACHINE DESIGN SERIES
PENTON

"PRODUCTION PROCESSES"
THEIR INFLUENCE ON DESIGN
Vols. I & II . . . *by Roger W. Bolz*

Here's HOW *to actually design for* LOW COST *production*

One of the country's outstanding authorities on production processes, Mr. R. W. Bolz, has presented in two volumes the actual "keys" to designing for low-cost production. 56 different processes, covering nine big production areas, are comprehensively discussed in terms of design in 924 pages of text, charts and illustrations.

With the emphasis today so pointedly on cost reduction, and with production methods always so important a part of the cost picture, this "shop approach" to design can be your guide to lower costs while products are still in the drawing-board stage. In effect, these two usable encyclopedias of practical information bring production know-how right into the engineering room.

SEE BOTH VOLUMES **FREE** ON 10-DAY TRIAL *use order form, and get yours* **TODAY!**

Mass Production
Flame Cutting
Planing, Shaping and Slotting
Turret Lathe Machining
Swiss Automatic Machining
Drilling and Boring
Broaching
Abrasive Belt Grinding
Tumbling Barrel Grinding
Lapping
Metal Spinning
Roll Forming
Stamping
Rotary Swaging & Hammering
Die Forging
Die Rolling
Cold and Impact Extrusion
Cold Heading
Electroforming
Sand Casting
Centrifugal Casting
Plaster-Mold Casting
Powder Metallurgy
Rubber Molding
Welding
Seam Welding
Butt Welding
Heat Treating
Production Design
Contour Sawing
Automatic and Shape Turning
Automatic Screw Machining
Production Milling
Hobbing
Gear Shaper Generating
Production Grinding
Honing
Superfinishing
Brake Forming
Section Contour Forming
Deep Drawing
Wire Forming
Hot Upsetting
Hot Extrusion
Cold Drawing
Thread and Form Rolling
Metal Spraying
Permanent-Mold Casting
Die Casting
Investment Casting
Plastics Molding
Ceramics Molding
Spot Welding
Projection Welding
Brazing
Shot Peening

← **LIST OF PRODUCTION PROCESSES COVERED IN BOTH VOLUMES**

THE PENTON PUBLISHING COMPANY, Book Department
1213 West Third St., Cleveland 13, Ohio

Send me both volumes of "Production Processes" by Roger W. Bolz

☐ **On ten days trial for free examination. If the books meet with my approval I will pay $15 (plus tax if any). Otherwise, I will return the books in good condition, postpaid.**
☐ **Remittance enclosed* in which case the books will be sent postpaid.**

☐ **Bill me**
☐ **Bill my company**
☐ **C. O. D.**

Signed ____________ **Title** ____________

Company ____________

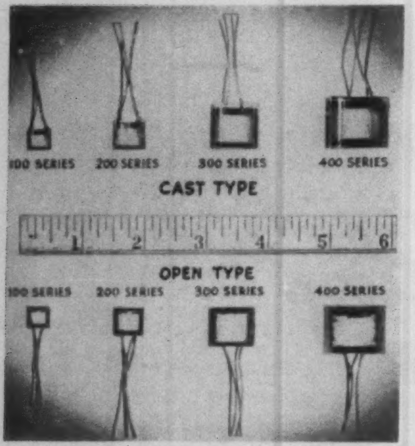
Address ____________

City ____________ **Zone** ______ **State** ______

***Please add 45c to cover State Sales Tax on orders for delivery in Ohio.**

common mounting bracket to save space. Two dc relays, or one ac and one dc relay may be used. Assembly holds contacts operated for any length of time without consuming power, operates contacts over one lead and releases them over another, and acts as an overload relay which is electrically reset from a remote point when tripped. In addition, it will act as an interlocking relay pair on either ac or dc combination. **C. P. Clare & Co.,** 3101 W. Pratt Blvd., Chicago 45, Ill.

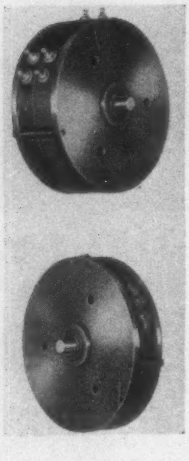
Circle No. 70 on Reply Card



Subminiature Transformers

Ranging in size from 3/8 x 3/8 x 11/32 in. to 3/4 x 7/8 x 1 in., a line of transformers features 32 models with power capabilities from less than 1 to more than 100 milliwatts. Units are designed for transistor and other miniature circuit applications. Four different sized series each contain input, interstage, choke, and output models. Each of the 16 basic units is manufactured in open and cast construction. Units are applicable to the audio and ultrasonic frequency ranges, and the smallest series is designed particularly for hearing aid use. Nylon bobbins are wound with as many as 6800 turns (400 ft) of wire, yet thickness of enamelled wire is as small as 1½ mils and laminations are minute. Temperature range of satisfactory operation is −25 to 100° C. Cast models are enclosed in thermosetting resin, and open models have a protective resin coating. **Texas Instruments Inc.,** 6000 Lemmon Ave., Dallas 9, Tex.

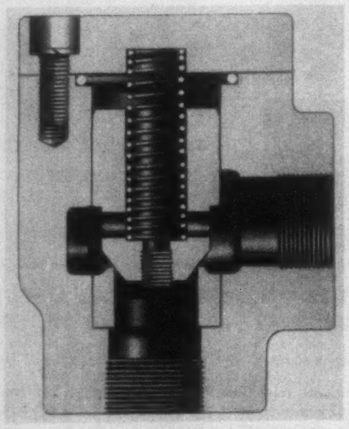
Circle No. 71 on Reply Card



High Resolution Potentiometer

Exceptionally high winding resolution is accomplished by a long winding length and a small diameter cylindrical winding in a new, low torque, linear potentiometer. Instrument is capable of fine settings and readings. Completely enclosed in molded Bakelite housings, these potentiometers can be used as single or multiple ganged units and can be provided with as many as 16 taps. Individual units can be staggered in 90° increments or unit contact brushes can be phased separately in various relationships. **Dejur-Amsco Corp.,** 45-01 Northern Blvd., Long Island City, N. Y.

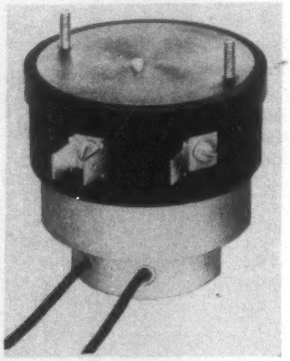
Circle No. 72 on Reply Card



Hydraulic Check Valve

Large area of a new line of 3000 psi hydraulic check valves permits unusually large flow volume. For instance, the 1½-in. model has a 104.2 gpm capacity at 15 fps. Valve allows free flow in one direction and prevents flow in the opposite direction. Models are available with pipe thread or flange connection, in ¼ to 1½-in. sizes, and with any position mounting. Valve may be spring closed, pilot operated, or pilot operated with pressure breaker. **Rivett Lathe & Grinder, Inc.,** Brighton 35, Boston, Mass.

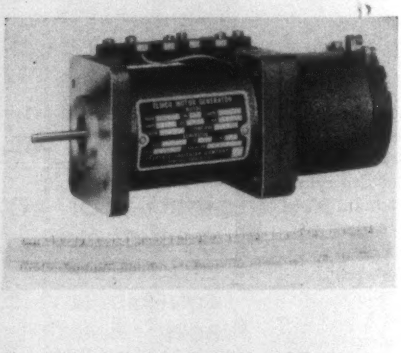
Circle No. 73 on Reply Card



Pushbutton Fixed Interval Timer

Pushbutton timer is easily mounted to operate in any position, will handle a fixed timed interval ranging from 15 seconds to one month. Timer is operated by a synchronous motor. Switch is rated 25 amp, 115 v, 60 cycle ac, turns load on when button is depressed, turns it off after the factory set time interval. Housing is compact and dust tight, 2¼-in. in diameter and 2⅛-in. deep. Terminals are quickly connected, heavy duty contacts are of solid silver, and cam, latch and operating button are of nylon. **Bristol Motor Div., Vocaline Co. of America, Inc.,** Old Saybrook, Conn.

Circle No. 74 on Reply Card



Low Inertia Induction Motor

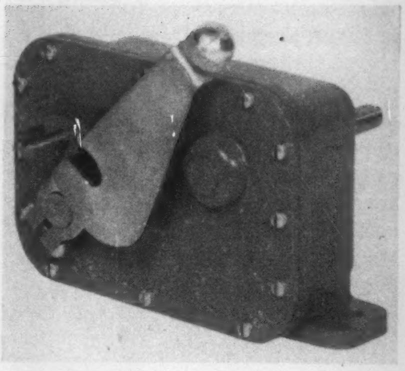
Induction servo motor with double-ended shaft provides a high torque-to-inertia ratio, low starting voltage, maximum torque at stall, and a low-inertia squirrel cage rotor which eliminates cogging at low speeds. Motor is 2-phase, 2-pole, 60-cycle with 5 w output, 5-oz-in. stalled torque and 5000 ohms control phase stalled impedance. By splitting the phase with a capacitor, this motor can be made to operate from a single phase source. Unit is furnished for 400 cycles per second operation, but can be designed to specifications. Weight is 23-oz. **Electric Indicator Co., Inc.,** Springdale, Conn.

Circle No. **75** *on Reply Card*

Variable Speed Transmissions

New models are available in a line of infinitely variable speed transmissions known as Zero-Max. Original models have input and output shafts on opposite sides of the unit, and 10, 15, and 20 in.-lb torque. New transmissions can be supplied with double output shafts, with input and output shaft on the same side of the unit, and with shafts opposite the standard unit (as illustrated). Special speed control arms are available in various lengths for all models, and special control arrangements including a spring return type. Engineering service is available to manufacturers requiring geneva-type cyclic motion, right-angle vertical gearing, or other special controls applicable to the Zero-Max line. **Revco Inc.,** 2 E. Franklin Ave., Minneapolis 4, Minn.

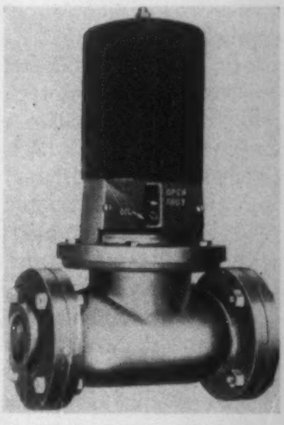
Circle No. **76** *on Reply Card*



Motorized Gas Valve

Line of motorized valves for automatic fuel control on gas fired boilers, furnaces, ovens, and other gas combustion systems features a spring loaded plunger and soft neoprene seat to assure fast, positive shutoff in case of electrical failure. Valve is equipped with two-wire motor operator and sturdy, lightweight aluminum body. Motor and plunger assembly can be removed easily for servicing without breaking line connections. Open or closed position of the diaphragm is shown by an indicator. **Eclipse Fuel Engineering Co.,** 1002 Buchanan St., Rockford, Ill.

Circle No. **77** *on Reply Card*

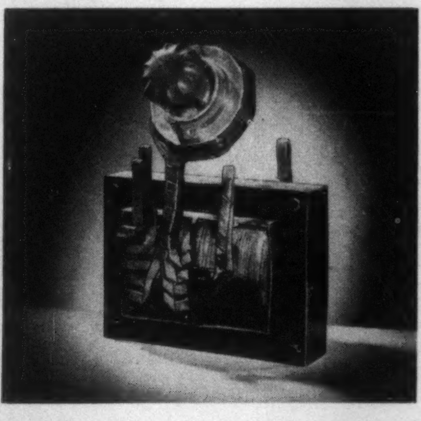


A Dependable Source of

SPECIALTY TRANSFORMERS

Power Type 50 Watts to 5 KVA

Class A or H Insulation



Can be furnished with 8-point tap changing switch. We invite your inquiry on transformers which will match your specific requirements.

THE STRONG ELECTRIC CORPORATION

96 City Park Avenue • Toledo 2, Ohio

QUALITY ELECTRICAL EQUIPMENT FOR A THIRD OF A CENTURY

STAMPINGS

Produced economically in our modern plant for:

AUTOMOTIVE, INDUSTRIAL EQUIPMENT, DOMESTIC APPLIANCE, AGRICULTURAL INDUSTRIES AND OTHERS; will boost your output at material savings.

Our production, engineering and toolroom facilities are geared to the volume usage of *your* industry.

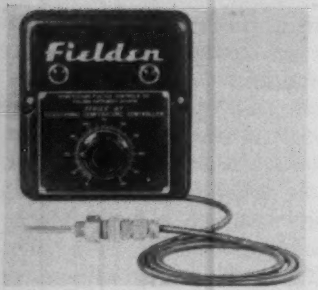
Send us your inquiries

LANSING STAMPING COMPANY

1157 So. Pennsylvania

Lansing 2, Michigan

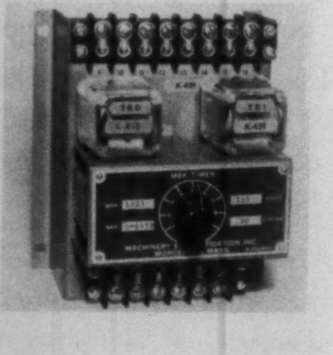
Serving Industry Since 1914



Temperature Controller

A two-zone electronic temperature controller is designed for a wide range of industrial applications such as petrochemical processing, plastic molding and extruding, explosives manufacturing and laboratory testing. Unit uses resistance temperature detector as a sensing device in bridge circuit in conjunction with high-gain-phase-sensitive amplifier relay unit. Single dial sets temperature control point, and red and green lights indicate temperature relation to set point. Single-pole two-way control contact handles 220 v at 5 amps. Standard ranges are listed but any range between −200° and +500° C can be supplied in conjunction with appropriate resistance bulb. Sensitivity is 0.1 F. Two vacuum tubes are used. Unit is encased in cast aluminum housing 6½ x 7½ x 4-in. **Fielden Instrument Div., Robertshaw-Fulton Controls Co.,** 2920 N. 4th St., Philadelphia, Pa.

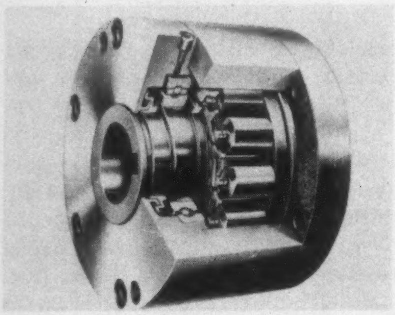
Circle No. **78** *on Reply Card*



Electronic Time Delay Relay

Plug-in relays which are protected from dust and dirt yet allow visual inspection of the relay operation are featured in a new electronic time delay relay. Open and enclosed units are available in two timing ranges. Cold cathode tube permits instant operation and eliminates warm-up time. Reset is instantaneous. Designed for interval timing and time limiting applications, the relay is easily adapted to complex timing sequences by connection with one or more additional units. Power consumption is 7 w and supply voltage is 110 v ac, 50/60 cycles. **Machinery Electrification, Inc.,** Northboro, Mass.

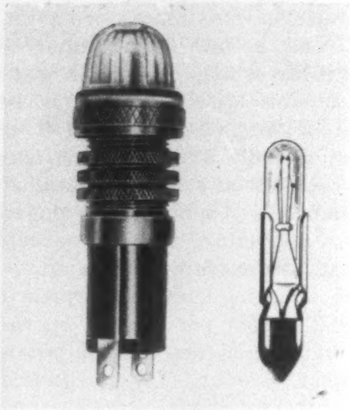
Circle No. **79** *on Reply Card*



Extra Heavy Duty Cam Clutch

Ball bearing overrunning clutch for indexing, backstop, and general duty applications can be used for dual drives, two-speed drives, centrifugal water pump drives, forced and induced fan drives, and ventilating fan drives in power plants, mines, steel mills, etc. Clutches have tapped holes in both ends for attachment to sprockets, gears, pulleys, or ratchet arms for drive requirements from 1300 to 6000 ft-lb. Toothed inner race driving member actuates independently sprung cams. Inner and outer races are hardened and ground. Hardened ball bearing steel cams have a gear tooth area on the inner side, a special outside surface that avoids galling, and a low locking angle that assures self-energization. Individual cam springs hold each cam in light contact with the inner driving and the outer race driven member, assuring even load distribution. Cam spring retainer lugs on a floating retainer provide stops against gear teeth on the driving member, guide the springs, and prevent them from being solidly compressed. Precision ball bearings insure concentricity between driving and driven members. **Morse Chain Co., 7601** Central Ave., Detroit 10, Mich.

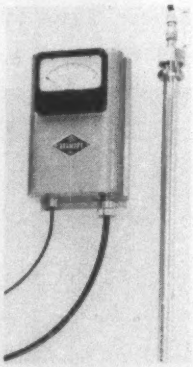
Circle No. **80** *on Reply Card*



Indicator Light

A line of pilot light assemblies now includes indicator lights for slide base lamps. Any telephone type incandescent bulb having a slide base can be utilized. No extractors or tools are needed when lamp needs replacing. Wide choice of screw and friction fitted caps with flat and convex lenses, ⅜ and ½-in. in diameter, are available. Pilot lights are equipped with soldering terminals or binding screws. For wide angle visibility on a panel, a screw cap with stovepipe lens of glass or plastic can be fitted over lamp and brought forward in the panel. **Dialight Corp.,** 60 Stewart Ave., Brooklyn 37, N. Y.

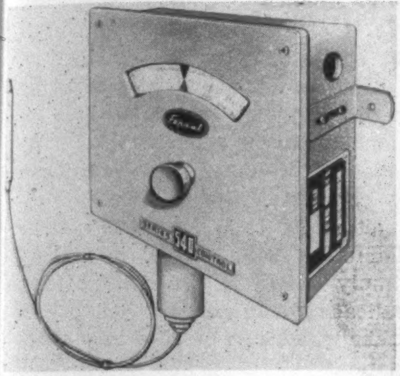
Circle No. **81** *on Reply Card*



Level Indicator

Utilizing a capacitive type sensing element probe, this device provides continuous indication of level for a wide range of materials in storage or process. No floating or moving parts, or contact-making electrodes are used. Indicator can be used with most nonadhesive chemicals, milk, oils, condensed gases, and refrigerants such as ammonia and the Freons. Operating temperature range is −425 to 500°F. Various probe lengths and materials are available to suit variances in rise and fall of materials, and character of substances involved. Separation between probe and equipment housing is usually 10 ft, but interconnecting coaxial cable can be as long as 1000 ft if necessary. Addition of remote indicating instruments over long distance telemetering circuits is possible. **Thermo Instruments Co.,** 1310 County Rd., Belmont, Calif.

Circle No. 82 on Reply Card

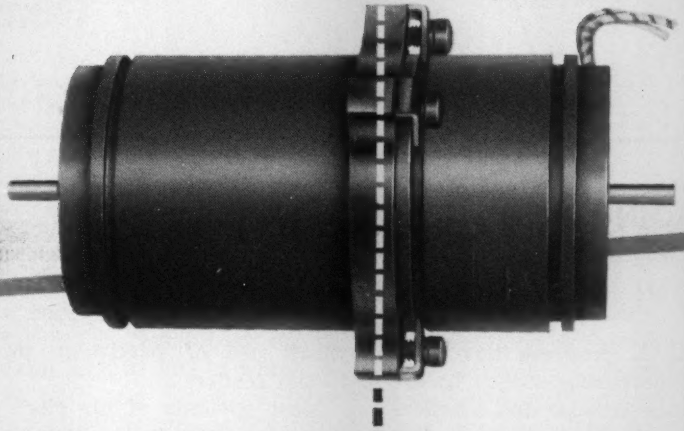


Indicating Temperature Control

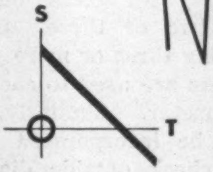
A remote indicating temperature controller for ovens and packaging or processing equipment features accuracy within 1 per cent of full scale. Operating range is 100 to 700F and sensitivity is uniform throughout the range. Double-pole, double-throw, 15 amp, 115 v power relay can be supplemented with an additional relay to control warmup heaters. Adjustable differential can be varied between 0.8 and 4 per cent of scale range, permitting adjustment of operating bandwidth of the controller to obtain a lower equipment cycling rate and longer equipment life. Temperature setting pointer and bulb temperature pointer pivot on the same axis and indicate against the same scale face for easy comparison of actual and set-point temperatures. Instrument operates on a liquid bulb and capillary system whose response to temperature change is transmitted to a bellows assembly and to the indicating pointer through a mechanical linkage. **Fenwal Inc.,** Ashland, Mass.

Circle No. 83 on Reply Card

GEARED FOR
FAST RESPONSE



Gear Reducer + Instrument Servo Motor



Now! **DIEHL** offers this Instrument Servo Motor with a Gear Reducer attractively priced for commercial applications in five different ratios. Either the motor, gear reducer or both can be quickly replaced avoiding costly down-time. The spur gear construction insures good efficiency.

GEAR REDUCTION RATIOS
191.1 to 1
79.6 to 1
32.4 to 1
13.8 to 1
5.8 to 1

SERVO MOTOR SPECIFICATION		
Output (Watts)	1	5
Frequency (Cycles)	60	60
Poles	2	2
Reference Phase (Volts)	115	115
Control Phase (Volts)	50	115
Reference Phase (Watts)	10	17
Control Phase (Watts)	3.5	17
Control Phase Impedance (Ohms)	555	575

Our engineering staff will gladly help you select the motors best suited to your specific requirements. A request on your letterhead will bring you a copy of Technical Manual No. A-0155 describing Diehl Servo Motors and related equipment.

Other Available Components:
D.C. SERVO SETS • RESOLVERS
MINIATURE PERMANENT MAGNET D.C. MOTORS

Diehl

DIEHL MANUFACTURING COMPANY
Electrical Division of THE SINGER MANUFACTURING CO.
Finderne Plant, SOMERVILLE, N. J.

AUTOMATION ABSTRACTS

AIR GAGING EVOLUTION

W. I. WILT and H. KIEFABER
Sheffield Corp.
Dayton, Ohio

INDUSTRIAL progress has been paced by increasing ability to divide the inch smaller and smaller. The truth of this statement becomes more apparent every year as the inch is divided into thousandths, ten-thousandths and today in many cases, millionths. These developments in modern measuring instruments can be classified into mechanical, electrical, electronic, optical and pneumatic methods of amplification, or combinations of these methods.

We shall confine this discussion to pneumatic methods and equipment, pointing out the new, broad developments rather than applications alone, which enable a better job of gaging to be done at less cost. Detailed information is available from the various manufacturers on specific developments which are of particular interest to the reader.

Most common of air gage tooling, of course, is the standard 2-jet gaging plug for checking true diameter, taper, out-of-round and bell mouth. This type of plug usually outlasts hundreds of plain gage plugs, yet costs only as much as two or three. Gaging plugs having three or more jets or annular jets are used to check average diameter. Similarly, such jets may be incorporated in air rings to check outside diameter, either true or average. Air snaps are also used to check external dimensions. Squareness of bore with face, camber or straightness, and thickness are other common applications.

Single-jet applications may be less familar and these are illustrated first so as to make it easier to understand various gaging cartridge applications to be described. *Fig.* 1 shows schematically single-jet applications of air gaging.

The combination or computing gage, *Fig.* 2, compares two or more separate dimensions. The taper of this bore is determined by comparing the value of the diameters at each end. The same diameters and taper are more simply shown on the right by two indicating columns parallel to each other which can be read at a quick glance.

A gaging head in which balls contact the work and control the flow of air from the jet is used for rough surfaces (over 65 microinches), for accurately measuring porous parts such as cast iron or powdered metal where air leakage could introduce an error, for lands more narrow than the width or diameter of conventional air jets, and for getting just into the mouth of the hole.

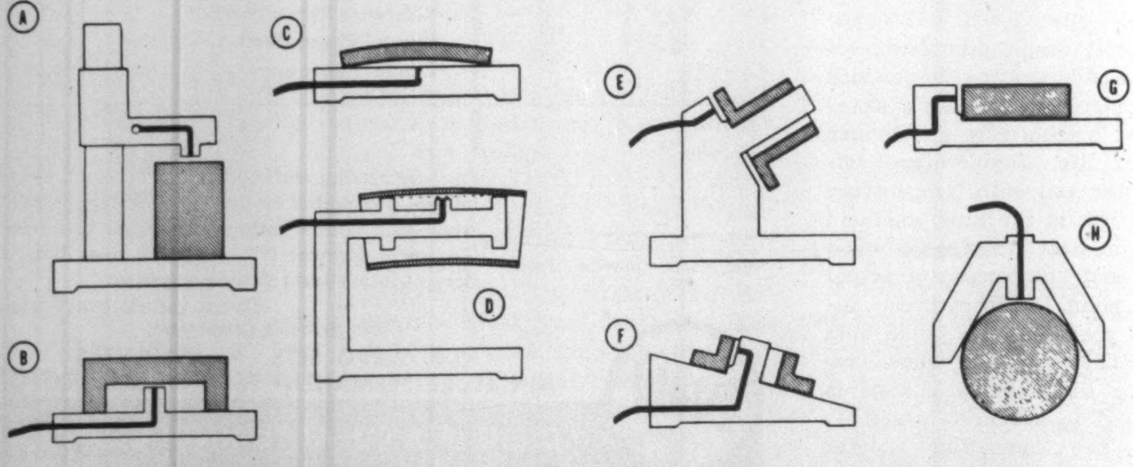


Fig. 1—Single jet applications (A) height gage; (B) depth gage, which may be used to check flatness; (C and D) straightness or flatness gage, also usable to determine bow; (E and F) squareness gage, long and short bores; (G) gage measures squareness of an outside face; (H) snap gage for measuring OD of shafts and cylinders

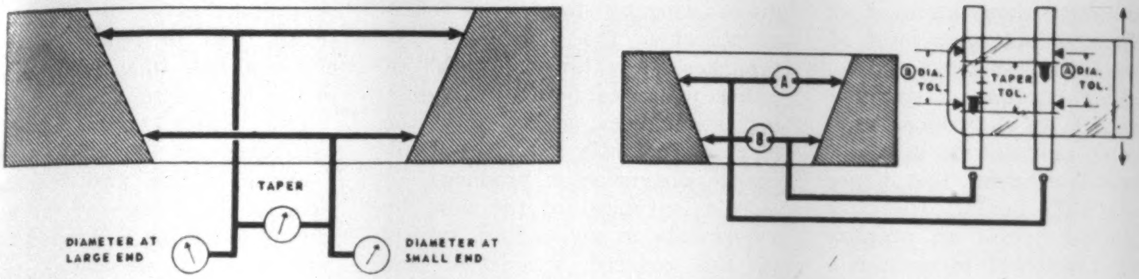


Fig. 2—Taper of this bore is determined by comparing measurements of diameters at each end. These measurements are shown on dial faces on the left and, more simply, by air columns on the right

An air indicator in which the only moving part is the contact arm and its extension pivoted on an elastic hinge is used to obtain an accurate check of runout on a machine tool spindle. This gage brings to production high amplification and accuracy heretofore impossible with the conventional indicator. It can be used in static strain gages, in dynamic strain gages, with recording units, as a center pickup unit in jig borers and other machine tools, for measuring the thermal expansion and magnetostrictive qualities of various materials and in height gage measuring on a surface plate.

Multiple gaging need not be confined to small parts. It can be utilized in checking the dimensions of shafts, crankshafts, cylinder blocks, etc.

Standard air gaging equipment is being made for use by bearing manufacturers and users to check radial play of all sizes of bearings using interchangeable arbors. Standard basic instruments with interchangeable tooling is also made to check the bearing components, and provide for effective matching of inner and outer rings with proper ball size for a predetermined amount of radial play. Typical of the matching efficiency is a day's run of 2,000 assemblies with rejection of only four assemblies.

Multiple gaging is a natural outgrowth of single-dimension checking and the forerunner of automation gaging. An example of multiple gaging is a case in which 30 gaging cartridges are clamped in a fixture for checking a jet turbine blade. These cartridges can be easily rearranged in case of an engineering change or the substitution of a completely new and different part. These gaging cartridges are connected to a 30-column air gage. Float patterns indicate dimensional quality of the air foil, thickness of the blade, whether it is centralized on its root form, and if not, in which direction and how much, whether and how much it leans to the right or left, or is tilted from front to back, or is bowed in the middle. It not only shows these conditions, but it tells exactly how much they deviate from the theoretically perfect. The actual size of any single dimension is shown. In this way corrective steps can be made in production processes.

Automatic Inspection

It is a rather simple step from multiple to completely automatic gaging and segregating where electropneumatic gaging heads are used instead of indicating dials or columns. These heads convert pressure changes caused by size variations into signals that actuate size-sorting or acceptance and rejection mechanisms.

Examples of the application of electropneumatic heads are the "autopneumatic" piston pin checking machine, the automotive push-rod segregator, and the 30-cal cartridge automatic gaging and segregating device.

In gaging fully loaded 90-mm rounds the shell is loaded into one end of the gage and is carried through the gaging station where it is checked with a two-section chamber gage simulating the actual 90-mm gun chamber. Accepted shells go out of the gage on one conveyor. Rejects are automatically shifted over to another conveyor which carries them out of the machine. If the shell passes the gage, it is impossible for it to jam in the gun chamber. This is the biggest gage believed ever to have been built. It weighs 20 tons, and illustrates to what size capacity automatic gaging has progressed. And savings are just as big. One estimate of a year's production of 1,800,000 rounds shows a manual gaging cost of $90,000 against $14,000 by this method, or a saving of $76,000, substantially more than the price of the machine.

A self-contained electropneumatic unit has been developed, which can be mounted on machines for automatic gaging and machine control. It can be installed by the gage-maker, the machine tool builder, or by maintenance people under the supervision of tool engineers. It needs only to be connected to an air line and proper electrical circuit and to be fitted with air tooling. It can be integrated into the electrical circuit of a machine to control the complete machining operation so that the part is brought automatically to size. It can be connected to solenoid - actuated mechanisms for completely automatic inspection, classification, and segregation of parts by dimensional size, or it can be used separately as a gage. And it can be tied into an automatic feedback system for automatic machine control.

This unit consists of an electropneumatic gaging head, a pneumatic indicating dial head, air manifold, variable restrictor and two signal lights, all mounted in a metal housing about 12-inches high, 8-inches wide and 6-inches deep. It can be set for any tolerance ranging from fifty millionths to forty thousandths of an inch, which should cover most of the normal requirements.

A typical example of automation gaging is an electropneumatic gaging unit mounted on a Micromatic honing machine that gages each part after honing, energizes a red light to show an oversize hole and a solenoid to operate a reject mechanism. A white light is energized to indicate within tolerance. A green light indicates a hole smaller than minimum tolerance limit and a reject mechanism is actuated. This is positive insurance against production of scrap, and the lowest possible combined cost of production and gaging.

In a more advanced step, three piston pin holes are precision bored simultaneously, then automatically moved to the right. The electropneumatic mechanism automatically moves three gaging spindles, each containing two sets of jets, into gaging position, so that both holes in all three pistons are gaged simultaneously. The tolerance is 0.0004-in. and red and green warning lights are energized when the dimension approaches to within a "tenth" of either tolerance limit. The gaging mechanism shuts down the machine instantly if an out-of-tolerance dimension is produced.

This is typical of the new developments in air gaging, typical of the reduced production and gaging cost possible.

Gaging Cartridge

Prior to development of the air gaging cartridge, pneumatic gaging was not generally considered for broad-tolerance gaging because of the 0.005-in. range limitation. With the air gaging cartridge wide new fields of application have opened to tolerances ranging from 0.001-inch up to 0.100-inch and greater.

The gaging cartridge is a precision variable orifice consisting of a spring actuated plunger having a limited range of travel which controls the flow of air through an orifice. The change in air flow is proportionate to the plunger travel, and is read directly as either a flow or pressure change in the air gaging instrument.

Two major types of gaging cartridges are currently available—normal action and reverse action. As the plunger of the normal gaging cartridge is pushed in, the flow of air is decreased, causing the float in the air gage column to fall. In the reverse air cartridge, as the plunger is pushed in, the flow of air is increased, thereby raising the float in the air gage column.

The air gaging cartridge was developed originally in 1949 as a means of inspecting jet turbine blades and buckets for which no satisfactory way of inspection on a production basis existed. No other truly accurate production inspection means exists even today. A 19-column instrument indicates quality of the air foil at the three generating levels; variation in thickness at nine datum points; centrality of the air foil; bow; lean and tilt, all relative to the root form. A rapid rate of inspection (300 to 700 pieces per hour) is possible by combining dimensions and conditions of the blade into an envelope tolerance containing the tolerances for bow, lean, and twist, all being confined between two limits for which markers are set up on the air gaging instrument. Air operated cylinders in sequence clamp the blade in the holding fixture and move the ball slide mounted air cartridge platforms into gaging position.

Although the operator maintains the high rate of inspection by attributes, each individual dimension and condition can be analyzed on the same gage to detect trends in processing, or the same information can be used for quality control by variables.

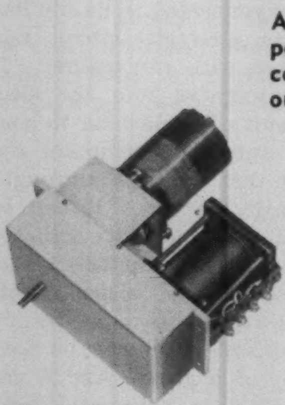
Nearly 800 such gaging assemblies, employing from 2 to 30 gaging cartridges each (nearly 10,000 altogether) are now in use for jet turbine blade and bucket inspection alone, greatly reducing the cost and maintaining desired practical quality of blades.

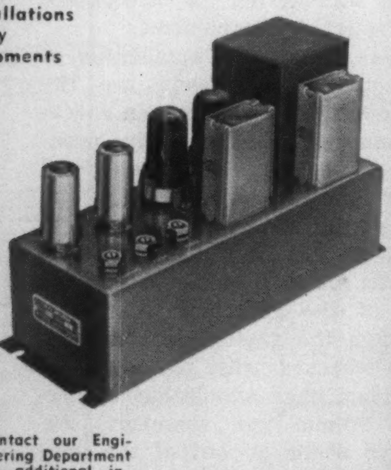
Over the last few years machine tool manufacturers have continued to improve their machines considerably relative to

Servo "Muscles"
for your
AUTOMATIC CONTROL SYSTEMS

Avoid development delays and expense with our line of universal servo components, and the cooperation of our Engineering Department, in your

- Industrial Controls
- Nuclear Installations
- Military Equipments





Standard servo amplifiers mate with various motors and clutches, and are driven from DC, 60 or 400 CPS data. Vacuum-tube, magnetic, and transistor-magnetic units available.

SERVO AMPLIFIER
TYPE SERIAL
ICO INDUSTRIAL CONTROL COMPANY
WYANDANCH, L. I., N.Y.

Contact our Engineering Department for additional information.

MIDLAND 3-7548

flexibility and increased production. Now there is the further great opportunity to make major progress toward assisting the operator in control of slide movement. The development of air cartridge makes possible a new type of machine control often referred to as the "feed" gage.

Applied to an external grinder, the gaging cartridge is mounted on the wheel head slide and is actuated by contact with a fixed adjustable stop which is mounted on a stationary part of the machine. In operation, one workpiece is first ground to within range of a comparator and gaged for actual size. The fixed adjustable stop is then adjusted to position the indicator in the air gage according to the results found by gaging the first piece. The workpiece is again loaded into the machine and the slide is adjusted until the air gage reading is at zero, indicating the part is to the required size. All succeeding parts are ground for zero position. A comparator or airsnap is used to gage the parts after grinding. When wheel wear is indicated after grinding a number of parts, the fixed adjustable stop is changed accordingly. With very little experience on the part of an operator, adjustment for wheel wear can be made on a constant basis and a sampling plan of inspection of the parts instituted.

In conclusion, anything that can be measured can be automatically controlled—and there are fewer things that cannot be measured.

From a paper entitled, "New Concepts of Gaging and Inspection" presented at the Annual Meeting of ASTE in Philadelphia, Apr. 1954.

ENGINEERED MAINTENANCE FOR THE MODERATE SIZED PLANT

C. N. LANIER, University of Delaware, Newark, Del.
J. D. QUINN, E. I. du Pont de Nemours & Co., Wilmington, Del.

MAINTENANCE, sometimes described as the ill-gotten progeny of the power age and mechanized labor, becomes increasingly significant as we develop more and still more labor saving devices in an economy where hand labor is relatively scarce. Maintenance is beginning to command the attention of industrial firms, large and small.

First stage of maintenance might be called the "emergency" approach. The philosophy, if any, behind this approach was to accept the fact of maintenance reluctantly and without enthusiasm, to operate buildings and equipment until they required repairs, then repair them. This is the "patch-and-run" situation.

Next stage is generally referred to as "preventive maintenance," a phrase which is widely used today as the hallmark of modern pro-

free! the most widely used ELECTRONIC SUPPLY GUIDE

send for ALLIED'S 1955 CATALOG

Simplify and speed *all* your electronic supply purchases. Order from the world's largest stocks of electron tubes (all types), test instruments, audio equipment, electronic parts (transformers, capacitors, controls, etc.). Our expert Industrial supply service saves you time, effort and money. Send today for your FREE 308-Page 1955 ALLIED Catalog.

HEADQUARTERS FOR RAYTHEON ELECTRON TUBES FOR INDUSTRY

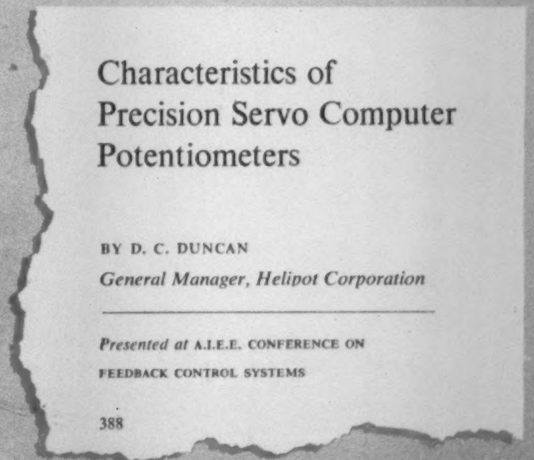
WE STOCK *all* types of RAYTHEON special-purpose electron tubes, diodes and transistors for industrial, broadcast and government use. To save time and money—phone, write or wire us—and we'll have your RAYTHEON tubes on the way to you in just hours. RAYTHEON special-purpose tubes are *always in stock* at ALLIED for quick delivery.

ALLIED RADIO
100 N. Western Ave., Dept. 80-A-5
Chicago 80, Illinois

Send for FREE Catalog

Write today for your free copy of this Technical Paper.

ask for data file 112



Characteristics of Precision Servo Computer Potentiometers

BY D. C. DUNCAN
General Manager, Helipot Corporation

Presented at A.I.E.E. CONFERENCE ON FEEDBACK CONTROL SYSTEMS

388

Helipot *first in precision potentiometers*

Helipot Corporation / South Pasadena, California
a division of BECKMAN INSTRUMENTS, INC.

gressive management. Preventive maintenance recognizes that there is a close relationship between usable equipment and output, and that the emergency approach might well find the machine out of service at a critical time. Therefore repairs and overhauls should be anticipated and scheduled. That maintenance, in other words, should be undertaken before the emergency occurs.

It is unlikely that industry will ever be rid entirely of emergency maintenance. Nevertheless, this work can be reduced to a practicable minimum. Preventive maintenance takes the correct approach but requires a bit of refining. The process of reducing emergency maintenance and refining preventive maintenance constitutes the third stage of maintenance development. This might be called "engineered maintenance." The objective is that of reducing the maintenance work load to the lowest point consistent with optimum output of the producing facility.

Some of the larger plants have found it possible to derive the necessary knowledge by a careful analysis of work orders as they are related to various pieces of equipment. This becomes a valuable equipment history. This history can be used to point out equipment which requires most attention. Furthermore, a properly classified record will soon underscore any weak points in a particular piece of equipment.

Another valuable practice is that of preplanning and scheduling. It should be possible to anticipate a large enough proportion of a week's work to establish priorities and to schedule the work force with a minimum of lost time.

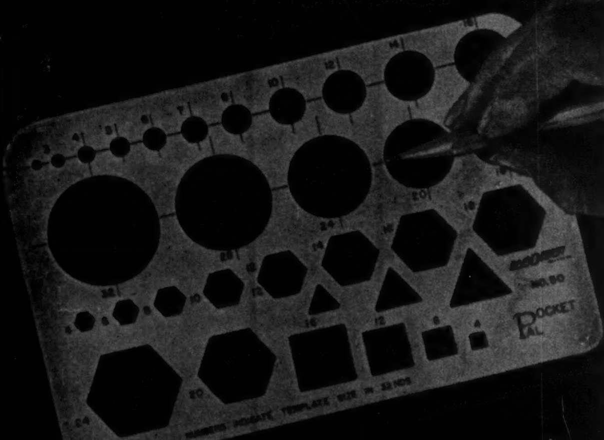
There is frequently the tendency of the moderate-sized-plant operator to conclude that such methods are too complicated, too costly, or just not applicable to his situation. It is doubtless true that not everything accomplished by a maintenance force of 500, for example, can be accomplished in the same way by a force of 30. Nonetheless, it is our purpose to indicate some basic practices and procedures which have been found successful in large plants and to suggest how they might be adapted to moderate-sized plants, perhaps even to small plants.

Sources of Assistance

There are some practices, particularly suitable for the moderate-sized and small plants, which may not be generally known. It is possible to obtain insurance contracts which will indemnify the insured for losses resulting from equipment breakdown. The insuring company, to protect its interests will provide the necessary maintenance for equipment.

It is possible, also, to obtain excellent assistance from suppliers of equipment and materials. Training programs are made available by producers of such devices as control instruments and servomechanisms. Furthermore, careful investigation of lubricating needs by a supplier of lubricants might well result in reducing the number of oils and greases required, as well as in selecting the

Partners····YOU AND YOUR
NO. 50 POCKET PAL



$1.00 AT YOUR LOCAL DEALER
CATALOGUE NO. 49 AVAILABLE UPON REQUEST

.030 MATTE FINISH MATHEMATICAL QUALITY DOUBLE-CURED PLASTIC.
ALL HOLES SMOOTH-MILLED TO ENGRAVING MACHINE ACCURACY.

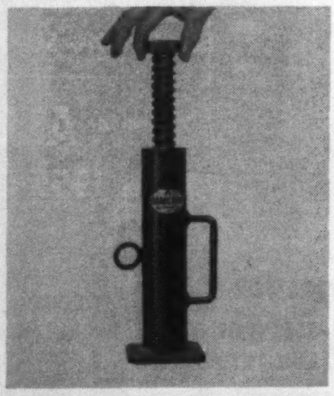
ONE OF MORE THAN 30 RAPIDESIGN TIME-SAVER TEMPLATES — ALL
OF WHICH ARE BETTER MADE, MORE USEFUL AND LESSER PRICED.

RAPIDESIGN INC.
P. O. BOX 592 GLENDALE, CALIF.

HAMILTON AUTOMATIC JACK
FAST-SAFE

TO RAISE PULL UP

TO LOWER TURN UP



Automatic
JACK
FOR
MACHINE SET UP BLOCK
LAYOUT SET UP JACK
PRESS SAFTEY BLOCK

Hamilton Automation Inc.
7490 EDISON AVE. ① HAMILTON, OHIO

AUTOMATION

The Magazine of Automatic Operations

gateway to the entire automatic operations market

AUTOMATION Magazine covers all phases of automatic production—cuts across all industries. Big now—the rate at which this market is growing—indicates a tremendous growth opportunity for any product or service that can help make operations more automatic. The time to hit this market hard in AUTOMATION is 1955.

needed by the men who are automating their production

They have the green light for full speed ahead on more automatic production to cut costs—raise quality standards. Now they urgently need more information on the fast moving developments in this field—more information on what your product or service can do to help. The high reader interest they have in AUTOMATION Magazine can be documented by hundreds of letters from management, production and engineering executives throughout every industry.

fills the gap in information sources

Busy men charged with the responsibility for revamping their production set-up have wanted one source of authentic information on automatic production. Now this gap has been filled by AUTOMATION Magazine. Concentrating solely on the task of encouraging and helping all industry achieve more automatic production, AUTOMATION has overnight become "must reading" with the very men you want to reach.

quickest way to more sales for:

- Conveying Equipment
- Data Handling Equipment
- Gaging, Testing and Weighing Equipment
- Hydraulic & Pneumatic Controls and Parts
- Handling, Feeding and Indexing Devices
- Instrumentation and Components
- Machine Fixtures, Components and Special Devices
- Motors, Drives and Controls
- Plant and Process Designers and Builders
- Special Machinery and Machine Tools
- Visual and Audible Signal Devices

If you have a product that fits this market, put AUTOMATION Magazine on your '55 schedule to help you get the jump on competition.

this audience across all industry has one common goal—more automatic operations!

For complete information see our new Data File.

the exciting challenge of automatic operation
data file on
AUTOMATION

SIC NO. AND DESCRIPTION	Total	Copies in Company Name	Corporate Officials and Gen. Mgrs.	Mfg., Production and Processing Mgrs. and Supts.	Engineering Dept. Heads and Design and Plant Engineers	Purchasing, Sales and other Personnel
10-14 Mines	522		44	404	74	
20 Food and Kindred Products	1340	6	210	203	917	4
21 Tobacco Manufacturers	62		10	9	43	
22 Textile Mill Products	965		203	97	664	1
24 Lumber and Wood Products	403		112	66	225	
25 Furniture and Fixtures	181		44	42	95	
26 Paper and Allied Products	734	1	98	126	508	1
27 Printing, Publishing and Allied Industries	179		14	28	134	3
28 Chemicals & Allied Products	1348	9	173	281	884	1
29 Petroleum & Coal Products	427		27	68	332	
30 Rubber Products	211		20	34	157	
31 Leather & Leather Products	213		37	26	150	
32 Stone, Clay & Glass Products	765	1	78	157	529	
33 Primary Metal Industries	1482	6	479	447	545	5
34 Fabricated Metal Products	1547		522	350	672	3
35 Machinery, except Electrical	5187	12	1657	843	2625	50
36 Electrical Machinery, Equipment & Supplies	1950	12	471	381	1056	30
37 Transportation Equipment	1732	26	379	524	791	12
38 Instruments, Optical Goods, Watches & Clocks	605	6	154	116	321	8
39 Miscellaneous Manufacturing Industries	227		41	41	143	2
89 Consulting & Industrial Engineering Firms	937	4	624	6	290	13
Miscellaneous Industries including Ordnance, Banks, Insurance Companies, Educational, Trade Associations, Libraries, etc.	40	13	9	2	7	9
TOTAL	21057	96	5406	4251	11162	142
PERCENTAGE	100.00	0.46	25.67	20.19	53.00	0.68

If your product belongs in automatic operations, your advertising belongs in

a Penton publication

AUTOMATION

The magazine of automatic operations

Penton Building, Cleveland 13, Ohio

AUTOMATION
CONSULTING
SERVICE

GEORGE H. KENDALL
Consulting Mechanical Engineers
SPECIALISTS IN AUTOMATION
PROCESSES
CREATORS OF THE FAMOUS
MULTRA MACHINES
FOR MACHINE ASSEMBLY
P. O. Box 3 *(Est. 1923)* Tel. Darien 5-1504
Noroton Heights 3 Offices Darien, Connecticut

WHEELER ASSOCIATES, INC.
- *Automation*
- *Operations Research*
- *Materials Handling*
- *Plant Layout*
- *Engineering*
- *Design*

"Designed to Reduce *Your Cost"*
15017 Detroit Ave. Cleveland 7, Ohio
Telephone—LAkewood 1-0300

GEORGE H. KENDALL
Consulting Mechanical Engineers
Methods Studies: Process or Product Redesign Existing Products for Greater Profit. Trouble Shooting Production, Design, Cost Problems. Specialist Automatic Machinery, Process, Controls, New Developments, Patent Studies, Investigations, New Products & Process Engineering Studies
P. O. Box 3 *(Est. 1923)* Tel. Darien 5-1504
Noroton Heights 3 Offices Darien, Connecticut

PROFESSIONAL
SERVICE
CARDS
NOW AVAILABLE IN
AUTOMATION

It has become very evident that Consulting Engineers are playing an increasingly important part in automation.

A survey now being completed indicates that half of the plants employing over 250 or with a financial rating over $1,000,000 plan to "install automatic facilities during 1955."

It also indicates that *twenty-one per cent* "plan to use services of outside automation specialists." Because of this very high interest we will include standard professional service cards in all future issues of AUTOMATION.

The rates are $16.00 per month on yearly basis, $18.00 on nine months basis, $20.00 on six months basis and $22.00 on three months basis (minimum).

AUTOMATION

correct lubricant for the job it is expected to do.

Another source of help for the smaller maintenance departments may be the production-department mechanical development engineer. He can offer his professional advice from a wealth of knowledge of production problems. He should be particularly interested in helping to increase production through improved maintenance.

Still another source of engineering assistance is available from technical graduate schools. A competent graduate student could spend a summer doing developmental work in the maintenance program for a moderate-sized plant. The results of his work should be beneficial to all concerned.

Systematic Method

Many moderate and smaller-sized plants do not have a sufficient volume of maintenance work to justify employment of specialists or staff engineers for development and installation of an extensive system of procedures, controls, and records that will permit this analysis. However, regardless of the size of the plant, it is necessary to develop a systematic method of conducting the maintenance operation and to accumulate data if the operation is to be improved. Certain developments in larger plants can be adapted readily for the moderate-sized plants.

Four of these developments are as follows:

1. The classification of work.
2. The weekly-daily schedule plan.
3. The equipment history for analysis of repairs.
4. The job procedures for improved performance.

A proper type of work order is a basic requirement. Most plants use some form of repair order, job order, or maintenance work order. The kind of form is not important but it should contain at least the following three items which provide the information required for analysis:

1. An adequate description of the work requested.
2. The inclusion in every order for repairs to equipment, an identifying reference to the equipment by name and/or equipment-piece number.
3. A proper classification of the work requested. For this purpose four categories should be considered: (a) repairs; (b) new work or alterations; (c) general maintenance of buildings and services; (d) services to operations. Based on the classification, accounting codes or code suffixes can be assigned to segregate costs for different types of work.

Next consideration is the effective planning of maintenance work. A system of scheduling work is always desirable but often not considered feasible for small organizations because of the paperwork involved. There is a simple method of scheduling that can be considered for maintenance groups large or small.

The schedule sheet can be prepared weekly with a sufficient number of copies to eliminate all daily transcribing of the description of work, codes, estimated hours, and craftsmen's names or numbers, or both. This combined weekly-daily schedule allows sufficient latitude for the foreman to select the men best-suited for the work and available on the particular day when the work should be performed.

Obviously, there are times when it is necessary to perform work which may not be anticipated when the weekly schedule is prepared. This work, usually classified as unscheduled work, can be added to the schedule sheet for the particular day. A weekly review will establish the percentage of scheduled and unscheduled work performed and indicate how effective planning has been.

When work is scheduled on a weekly basis, there is adequate time to plan related shopwork and to make sure of the availability of material, tools, and equipment.

Accumulation of Data

Costs of repairs can be compiled through accounting, but for a worthwhile analysis of work performed an equipment-history system is a requirement. For the smaller plant a simple form of equipment-history system can be developed. This requires only a different method of filing completed repair orders. Usually the orders are filed numerically or chronologically, and the only change is to file them by equipment-piece numbers.

Of course it is necessary to accumulate data in this file for a period of three months to a year or more, depending on the frequency that work is performed, before any analysis is attempted.

Equipment-history analysis involves consideration of the total cost of repairs, the frequency of repairs, and particularly, the effect on production as justification for improvements. Many of the larger plants have endeavored to answer these questions through replanning of work and application of craftwork measurement. This required the development of basic time and method and summary time values and training of applicators in the use of them.

As the objective can be to establish a reasonable, though not necessarily an exact time value for maintenance jobs, there is a simpler method that can be considered by the smaller plants. Procedures can be established for minor and major repairs, as well as overhauls, to include a work schedule showing the number and kind of mechanics, the estimated hours, a complete listing as to tools, materials, and equipment, as well as a complete job write-up. Single job plans can be devised for such routine work as lubrication and inspection.

These various procedures are developed in co-operation with the foreman and can be completed as time will permit. They are issued in preliminary form and later rechecked to insure the practicability of the plan. Two important results of this approach are likely to be a significant decrease in the nonproductive time of mechanics, and an increase in equipment operating time.

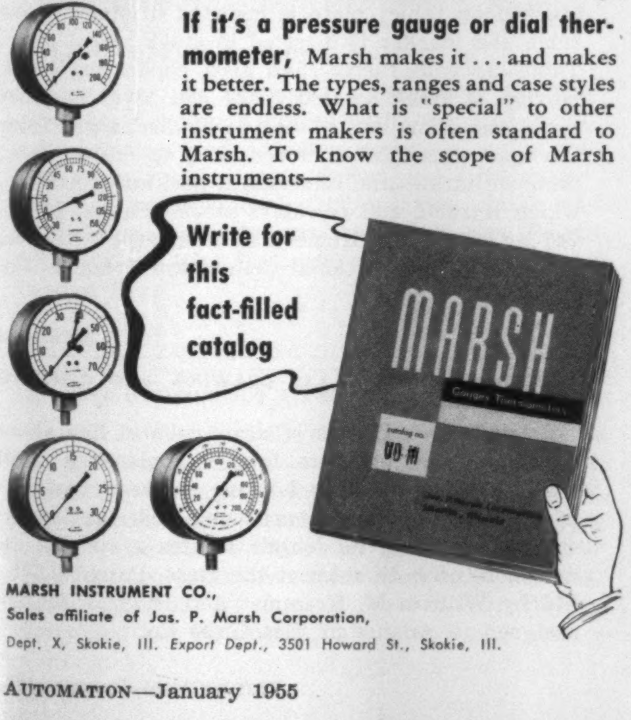
There are refinements such as backlog controls, control charts, and means of applying other controls to procedures that could be considered for any maintenance operation. However, the major items discussed can be adapted, and should provide a sound basic structure for a maintenance operation in the moderate and smaller-sized plants.

Engineered maintenance involves a systematic study of maintenance requirements and the adoption of good practices and procedures. It suggests that maintenance be considered with the same care and serious purpose as plant construction, plant operation, and product marketing. It undertakes to lower maintenance costs, but not at the expense of excessive breakdowns and lost production. It recognizes the value of "an ounce of prevention" but insists on knowing how often the preventive operation is necessary. And more than this, it is concerned with overall reduction in the work load in the long run. It refuses to be fatalistic and to accept present conditions as inevitable.

From a paper entitled, "Adapting Engineering Maintenance to Moderate-Sized Plants" presented at the Annual Meeting of ASME in New York, Nov.-Dec. 1953.

MARSH MAKES IT!

If it's a pressure gauge or dial thermometer, Marsh makes it . . . and makes it better. The types, ranges and case styles are endless. What is "special" to other instrument makers is often standard to Marsh. To know the scope of Marsh instruments—



MARSH INSTRUMENT CO.,
Sales affiliate of Jas. P. Marsh Corporation,
Dept. X, Skokie, Ill. *Export Dept.*, 3501 Howard St., Skokie, Ill.

New Ametron

MINIATURIZED RECORDING DIGITAL COUNTER

6"
12"
12"
Ametron

Compact
Sturdy
Economical

- Accumulates and records in printed form digital information
- Accepts pulses at rates up to 1000 CPM
- Prints on 2 inch wide tickets or standard 2¼ inch adding machine tape
- Automatic or manual reset available
- Both counting and printing circuits may be actuated by momentary closure of external contacts

Write for illustrated bulletin MD-43

STREETER-AMET COMPANY
4101 RAVENSWOOD AVENUE • CHICAGO 13, ILLINOIS
Branches in Pittsburgh, Allentown, Birmingham and Los Angeles

THE STANDARD OF ACCURACY SINCE 1888

AUTOMATION PATENTS

Copies of patents are available at 25 cents each from the Commissioner of Patents, Washington 25, D. C.

Controls

CONTROL MEANS FOR WEB SLITTING AND THE LIKE

Movable blade member in contact with edge of web, arranged with two switch elements each operable in one direction of web creep to control a mechanism for maintaining a predetermined aligned relationship between a travelling web and a transversely shiftable means for acting on the web. Patent 2,675,437 by Delbert A. Theobald, assigned to the Container Corp. of America.

ELECTRICAL CONTROL APPARATUS

Sequencing network control circuit for a welding machine requiring a flow of coolant during its operation. Includes time delay means actuated as a consequence of the actuation of the final sequencing step of said network for holding the coolant control means in its flow permitting condition for a desired time interval subsequent to completion of the sequencing operation of the network. Patent 2,676,230 by John J. Czaja, assigned to Weltronic Co.

AUTOMATIC CONTROL APPARATUS FOR MASS SPECTROMETERS

Adjustable means for providing an accelerating voltage for electrodes of the ion source; including means for producing a first reference voltage having a predetermined magnitude and a second reference voltage whose magnitude is a predetermined fraction of the accelerating voltage, and a servo system responsive to these reference voltages for controlling the adjustable means and causing the relative magnitudes of the reference voltages to be maintained in predetermined relationship. Patent 2,676,264 by Clifford E. Berry, assigned to Consolidated Engineering Corp.

AUTOMATIC FREQUENCY CONTROL SYSTEM

For comparing two periodic voltages; a pair of electron discharge devices each with anode, cathode and control electrode. Point of reference potential connected to both cathodes; a first alternating reference voltage of substantially constant amplitude impressed between each anode and point in opposite phase; a second source of periodic voltage impressed between the control cathodes and reference point in same phase; an output circuit responsive to peak voltage across said networks in series. Patent 2,676,256 by Jack L. Schultz, assigned to General Electric Co.

REGENERATIVE FEEDBACK CIRCUIT

Resonant input circuit and an unbypassed cathode resistor coupled in series arrangement between the control grid and cathode of an electron tube; an output impedance and an output capacitor connected to the anode of the tube; crystal forming an effective series resonant circuit (at the resonant frequency of the input circuit) is connected between the output capacitor and the cathode whereby signal energy equal to the input resonant circuit is fed back from the output circuit to compensate for the degenerative effect of the cathode impedance. Patent 2,675,432 by Wen Yuan Pan, assigned to Radio Corp. of America.

◆ ◆ ◆

Handling

APPARATUS FOR SEGREGATING STACKS OF SHEET MATERIAL FROM A CONTINUOUSLY FORMING SUPPLY OF THE MATERIAL

Folded sheet material is provided with incomplete lines of severance leaving breakable bonds at alternate folds. Material coming from folder is stacked on table; plate is inserted in stack above table and marker is inserted in stack above plate. Table descends faster than plate separating lower portion of stack so that blade can sever the material and allow lower stack to be discharged from the apparatus. Table moves back up under plate; plate withdraws and reinserts at position of marker, which retracts and re-enters stack. Patent 2,675,747 by Charles J. Greiner and Reinhardt N. Sabee, assigned to International Cellucotton Products Co.

◆ ◆ ◆

Machines

CONTINUES SHEET GLASS DRAWING AND COATING APPARATUS

Sets of spaced pairs of draw rolls in line above a mass of molten glass form a continuous sheet that passes through a housing between two sets of the rolls. Housing is arranged such that sprayers spaced along its length creates a coating atmosphere on both sides of the glass. Patent 2,675,646 by William M. Krammer and Hugh J. Marsh, assigned to Adamston Flat Glass Co.

Measuring

CHECK WEIGHING MECHANISM

Variable counterweight comprising a flexible member suspended from a movable scale beam and initially sufficient to overbalance a filled package. Depending end of counterweight is gradually lifted to reduce the effective counterweight and effect movement of the scale beam, which in turn terminates the movement of the counterweight reducing means and actuates means to record the weight of the package with relation to a desired predetermined weight. Patent 2,676,009 by Stanley R. Howard, assigned to Pneumatic Scale Corp. Ltd.

DEVICE FOR MEASURING THE THICKNESS OF SHEET METAL

A standard gaging head; an exploring head and reference plates; means maintaining the standard head a predetermined distance from one of the reference plates; means causing the distance between the exploring head and another reference plate to vary with the thickness of the material measured. The outputs of these heads are connected in opposition so as to obtain a signal, the phase and magnitude of which is dependent on the direction and magnitude of deviation between the standard and unknown. Patent 2,676,298 by Joseph C. Frommer, assigned to Electric Eye Equipment Co.

METHOD AND APPARATUS FOR MEASURING MATERIAL THICKNESS

Material is subjected to radiation from a source of energy and a detector which is substantially isolated from the source; is arranged on the same side of the material to continuously scan at a predetermined distance from the material and record the energy received. Patent 2,675,482 by Donald C. Brunton, assigned to Isotope Products Ltd., Canada.

◆ ◆ ◆

Packaging

WRAPPER MAKING MACHINE

Apparatus for preparing a wrapping assembly consists of a table equipped with: mounted supply rolls of sheet and adhesive materials, guide roll, pair of nip rolls, severing device, and drive means; arranged with hydraulically operated clutch and hydraulic actuator for the severing device. Patent 2,675,746 by John D. Conti, assigned to American Viscose Corp.

◆ ◆ ◆

Testing

MULTIPLE CONTINUOUS AIR SAMPLER

Anvil for temporarily clamping a film strip to the upper movable section of the sampling head is provided with means for creating a suction of atmospheric air, directing air-borne particles against the film strip which is then wound on spools to provide a permanent record for analysis. Patent 2,675,697 by John T. Quynn, John S. McNulty and Lee M. Buchanan.

WANTED:

Technical Editor

- A real challenge for anyone with enthusiasm for writing and a strong creative urge.
- Mechanical engineer with diversified design or manufacturing background and editorial or other writing experience.
- To develop, write, and edit articles and feature departments.
- Opportunity to travel in quest of editorial material.
- Headquarters in Cleveland, Ohio.
- If you are interested and feel qualified, please send full details of your practical *engineering and writing* experience to the Editor,

AUTOMATION, Penton Building,
Cleveland 13, Ohio.

CUMULATIVE EDITORIAL INDEX

Number preceding the hyphen is month of issue; those following are page numbers in that issue.

A

Abrasives manufacture, coated, 8-62
Absorption, radiation, 9-47
Accounting, 8-66; 12-31
Air cooling system, 1-30
Air gaging, 8-76; 11-21; 1-102
Air sampling, 1-111
Aircraft,
  automatic pilot, 8-129
  control, 8-55
  engines, 8-39; 9-113
Amplifier,
  diode, 1-45
  magnetic, 9-105; 11-112, 116
  servomotor, 9-49
Analog computer, 9-68; 10-96
  heat transfer, 9-34
Analog to digital conversion, 10-41; 12-98
Analog vs digital computer, 9-63
Analysis,
  dielectric, 12-108
  mathematical, 11-110
  process stream, 11-46
Analyzer,
  infrared, 9-47
  yarn, 9-70
Arbor, loading, 1-18
Armature manufacture, 10-21, 105
Assembly, 8-39, 120, 124; 9-22, 109; 10-23, 53; 11-12
Atomic energy, 9-69
Atomic Energy Commission, 9-107
Atwood, S. G.
  Layout for Handling, 10-46
Automatic control, 10-108
  basic characteristics, 9-65
  discontinuous, 8-139
  principles, 8-138
  terminology, 8-61; 9-65; 10-51; 11-59; 12-63; 1-49
Automatic elevator, 9-68; 10-104
Automatic machines, 8-34; 9-109; 1-16
Automatic systems, 11-47
Automation,
  application of, 9-21
  benefits of, 8-50
  concepts, 10-100; 1-10
  definition of, 8-34, 46, 156; 10-18
  development of, 8-46; 9-20
  elements of, 8-35
  history, 10-102
  in the office, 10-50; 12-31; 1-39
  job shop, 10-46
  planning for, 8-35, 37, 49, 50; 9-22; 10-18, 47
  process design for, 8-132
  product design, 8-72; 9-23, 51; 11-18
  steel industry, 11-107
Automobile manufacture, 8-48
Auxiliary operation, 11-30
  loading arbor, 1-18

B

Balancing, 10-38

Behrend, R. H.
  Assembling Low-Budget Jobs, 10-53
Berg, R. H.
  Continuous Weighing of Solids, 11-39
Bin, weighing, 11-39
Binary number system, 8-76, 78; 10-42
Bishop, L. J.
  Latex to Foam Rubber, Automatically, 11-31
Bols, R. W.
  The New Automation, 9-14
  Design for Manufacture, 11-18
  Indispensable Judgment, edit., 1-21
Bonding, induction heat, 9-72
Bottle sealing, 11-23
Bowling, 12-107
Bratton, E. W.
  Continuous Gaging, 8-62
Broaching, 11-14

C

Camera, 11-14
  oscilloscope, 1-12
Candle dipping, automatic, 1-22
Capacitance, 9-65
Capacitors, electronic, 10-109
Capacity, 9-65
Cards, punched, 8-82, 125, 130; 10-9; 12-106
Cartridges, air gaging, 1-102
Casting, 10-19
Chemical measuring, 8-120, 124
Chemical plant engineering, 8-150
Circuits,
  control, 8-142; 11-116
  etched, 10-11
  printed, 8-124
  servoamplifier, 11-64
  switching, 9-113
Cleaner, ultrasonic, 9-72; 12-102
Clock, setting mechanism, 9-110
Closed-loop,
  concept, 10-57
  systems, 11-111
Clutch,
  electric, 8-129
  electromagnetic, 9-71
Coal plant lubrication, 1-52
Coin,
  collecting device, 9-109
  controlled timer, 9-109
  operated device, 9-109
  weighing device, 10-38
Color sorting, 1-10
Common language tapes, 12-31; 1-39
Commutators, 9-109
Components, feedback systems, 9-60
Compounding, rubber, 9-50
Computers, 8-68, 129; 9-108; 12-109; 1-12
  analog, 9-34; 10-96
  component, 1-45
  control, 8-74; 1-9
  digital, 8-141; 10-108; 11-9; 12-14; 1-16
  elements, 10-97
  feedback systems, 9-62
  mechanical, 10-96
Condenser manufacture, 10-20
Console control, 12-42
Contacts, electrical, 10-13
Container, decorating, 9-37
Contents, 1-3
Continuous gaging, 12-57
Continuous production, acetylene, 9-64
Control,
  air pollution, 1-10
  aircraft, 8-55; 9-113
  centerless grinding, 12-61
  circuits, 8-142; 1-62
  closed-loop, 9-58; 10-96, 101
  computer, 8-74
  electric arc furnace, 12-96
  electrical, 8-51, 55, 129; 10-104; 11-116; 12-66, 106; 1-22, 110
  electronics, 8-80; 10-28, 34, 39, 44; 12-8, 53; 1-9
  feedback, 8-58, 63; 9-57
  film, 8-82; 9-66
  frequency, 12-106
  gage, 1-55
  hydraulic, 8-129; 10-104; 1-62
  instrument, 8-58, 122, 129; 9-108; 12-106
  machine, 10-98
  mechanical, 8-55
  motor, 8-129
  open-loop, 9-58; 10-96
  panel, 12-42
  parallel disk grinding, 12-62
  photoelectric, 8-60; 9-69; 10-35; 11-36
  playback, 8-79
  pneumatic, 10-34; 11-116; 12-53
  power required by, 8-80
  press unloader, 12-21
  quantitative, 8-59
  refinery, 12-53
  tape, 8-77 ,130; 10-28; 12-9
  temperature, 8-122; 10-104
  tension, 8-58; 9-106
  terminology, 8-61; 9-59, 65; 10-51; 11-59; 12-63; 1-49
  timer, 8-140
  tool, 8-51; 9-44
  traffic, 8-122
  weight, 1-13
Controllers,
  action, 12-63; 1-49
  adjustments, 1-49
  automatic, 8-61
  relay operated, 8-61
  self-operated, 8-61
Converters,
  analog to digital, 10-41; 12-98
  card to tape, 8-125; 12-37
  tape to card, 8-125; 12-37
Conveying, 10-47; 12-106
Conveyors, 8-60, 120, 132; 9-67, 70; 10-35, 105; 11-34
  belt, 8-48, 75; 9-109
  chain, 8-130; 9-109
  feeding, 12-41
  overhead rail, 8-38
  rubber, 1-9
  weighing, 11-39
Cooling system, air, 1-30
Counter, 12-107
Crusher, continuous process, 9-64
Cutoff machine, 8-131

D

Data processing, 8-66, 82, 123, 125, 130; 9-70, 108; 10-9, 12, 41; 11-9, 22; 12-31, 98, 106, 109; 1-12, 15, 16, 17, 39
Dead time, 9-65
Design, 11-116
Digital computers, 8-141; 10-108; 11-9; 12-14; 1-16
Digital vs analog computer, 9-63
Diode amplifier, 1-45
Discontinuous automatic control, 8-139
Distribution: See warehousing
Drive and control system, 1-31
Drive, electronic variable speed, 10-44
Drum, memory, 8-67

E

Economics, 8-35, 36, 51, 73, 148; 9-15, 22, 28, 113; 10-27; 1-33
Education automation, 9-70
Egg,
  cleaning, 9-109
  handling & sorting, 12-27
Electrets, 10-109
Electrical,
  arc furnace control, 12-96
  control, 8-51, 55; 10-104; 11-116; 12-66, 106; 1-22, 110
  engineering, 8-140
  power, 10-17
  timer, 1-70
  transmission, 10-103
  weighing, 11-40
Electronics, 1-12
  capacitors, 10-109
  control, 8-80; 10-34, 39, 44; 12-8, 53; 1-9
  diodes, 1-45
  measuring, 8-131
  modular design, 11-19
  servo, 11-61
  tube, 10-8
Electroplating machine, 11-12
Electrostriction, 9-68
Elevator, 9-68; 10-104
Engine manufacturing,
  aircraft, 8-39
  automobile, 8-48
  diesel, 8-120
Engineering,
  analysis, 9-112
  chemical plant, 8-150
  electrical, 8-140
  instrument, 8-140
  manufacturing, 8-54
  systems, 11-47
  timing, 8-140
Equipment,
  data processing, 12-32
  replacement, 8-150
Experimental method, 10-108

F

Feedback, 8-58, 61, 63; 10-57, 98; 11-49; 12-66
  control, 9-57
  speed control, 9-61
Feeders, 9-23; 10-52, 104; 11-116
  vibratory, 8-76
Film control, 8-82; 9-66
Finishing, 8-122
  steel, 11-108
Flowmetering of solids, 11-39
Foam rubber, 11-31
Foundry automation, 9-100
Frequency control, 12-106
Furnace, open hearth, 11-108

G

Gaging, 8-122; 1-111
  air, 8-76; 11-21
  continuous, 12-57
  cyclic processing, 1-55
  gear, 9-46; 1-16
  radiation, 8-62; 9-107; 11-108
  radioisotope, 9-67
  weighing, 8-59; 9-27; 1-11
  wire, 12-59
Garrott, P. B.
  Automation in Paperwork 12-31; 1-39
Gear shapers, film controlled 8-82
Gear shaving and gaging, 9-46; 1-16
Graphic panel, 9-18
Gyro, 8-55

H

Hadekel, R.
  Hydraulic and Pneumatic Servos, 10-57; 11-49; 12-43; 1-61
Hagen, G. E.
  Automatic Information Storage, 8-66
Hagerman, L.
  Attachment Automates Container Decorating, 9-37
Handling,
  aligning, 8-130
  conveying, 8-38, 130; 9-108, 109, 10-35, 47, 105; 12-27, 41, 97, 106; 1-9, 28, 57
  data, 8-66, 123; 10-9; 12-31; 1-39
  egg, 12-27
  feeding, 8-76; 9-20, 108; 10-52, 104; 11-116; 1-50
  orienting, 8-130; 10-35, 104; 11-20
  parts, 11-58
  radioactive, 9-41
  sand, 1-16
  sorting, 8-75, 76; 10-38, 104; 12-28, 107; 1-110
  unloading, 12-19; 1-50
Harder, D. S.
  Automation—A Modern Industrial Development, 8-46
Hardness testing, 11-10
Hauk, E.
  Attachment Automates Container Decorating, 9-37
History, automation, 10-102
Holtje, M. C.
  Feedback System Regulates Voltage, 12-66
Hopper, weighing, 11-39
Howard, S. R.
  Weight Controlled Volume Filling, 9-24
Hunting, 10-100
Hurni, M. L.
  Increasing Automation Opportunities, 8-69
Hydraulics, 9-41
  control, 10-104; 1-37
  elements, 9-42
  equipment, 1-31
  presses, 10-53
  servos, 10-57; 11-49; 12-43; 1-61
  systems, 9-45; 1-22
  weighing, 11-40

I

Index, turret, 9-39
Indexing, 8-146; 9-108; 10-53; 11-61, 116
Induction heating, 11-104
Inspection, 9-21; 10-28, 38
  automatic, 12-57
Instrumentation, 9-113
Instruments, 9-17
  control, 8-58, 129; 12-106
  engineering, 8-140
  measuring, 8-131
  recording, 8-129; 9-108; 1-110
  seismological, 8-141
Integrated data processing, 12-31; 1-39
Interchangeable manufacture, 11-18

J

Jaws, press unloader, 12-23
Job Shop Automation, 10-46
Johnson, E. S.
  Machine Mobility, 9-29
Johnson, R. N.
  Electrical Maintenance in Automation, 9-40
Joint Industry Conference, 8-52

K

Kendall, J.
  Remote Handling with Hydraulics, 9-41

with an account of the historical origins of these devices in the basic sciences and their allied arts. Dr. Hunt, who has experimented since 1937 with a space operator to restore symmetry in analysis of electromagnetic coupling, is able to give, by means of this device, a unified discussion pertaining to all types of electromechanical coupling, including magnetic, electric, and mixed transduction fields. Mostly new material is presented, including some of the results of wartime research at Harvard University sound laboratory. Previously unpublished data deals with topics such as: the origins of echo ranging, crystal oscillator, electrostatic transducers, and evolution of dynamic loudspeaker.

Government Publications

Some Applications of Ultrasonics to Industry. *Report* PB 111190 *by Office of Technical Services; 27 pages; U. S. Dept. of Commerce, Office of Technical Services, Washington* 25, *D. C.;* $.50.

This review of recent developments in the industrial use of ultrasonic energy points the way toward new applications in treating soiled cloth, cleaning metal surfaces and locating faults in metals. Ultrasonic waves are also finding application today in homogenizing food products and cleaning the air of dust, mist, smog, gases and acids. An extensive bibliography of the subject is included.

◆

Transistor Circuit Components. *Report PB* 114778 *by Wright Air Development Center; 22 pages, available from Library of Congress, Publication Board Project, Washington* 25, *D. C.; microfilm,* $2.25; *photocopy* $4.00.

Detailed survey on miniature electronic components for use in transistor circuits discusses components already available as well as those under development. Generally speaking, transistor circuits need capacitors, inductors, resistors and potentiometers of the same impedance values, precisions and stabilities as those used in electron tube circuits. However, advent of the power transistor will call for components of considerably higher power and current ratings. Also, introduction of the silicon transistor will create a demand for components that can operate at temperatures up to 200C. Full scale illustrations of many new experimental components are included.

◆

Progress Report on Reliability of Electronic Equipment. *Report PB* 111455 *by Committee on Electronics of the Research and Development Board; 20 pages; available from Office of Technical Service, U. S. Department of Commerce, Washington* 25, *D. C.;* $.50.

Volume 1 of this two-volume series stresses the critical role played in modern warfare by electronics equipment, the enormous increase in complexity of construction and difficulty of operation, and the serious problems resulting from these changes. This report makes specific recommendations for a reliability program to include better design, inspection, maintenance, and operating practices, and briefly surveys the evolution of military electronic equipment.

ADVERTISING INDEX

Aetna-Standard Engineering Co., The	20
Allied Radio	105
American Machine & Foundry Co., Potter & Brumfield, & Sterling Engineering Subsidiaries	116
Baker Raulang Co., The	2
Barnes, W. F. & John, Co.	79
Beckman Instruments, Inc., Helipot Corporation Division	105
Bellows Co., The	83
Binks Manufacturing Co.	81
Cleveland Tramrail Division, The Cleveland Crane & Engineering Co.	77
Diehl Manufacturing Co., Electrical Division of The Singer Manufacturing Co.	101
Dynamatic Division, Eaton Manufacturing Co.	87
Eaton Manufacturing Co., Dynamatic Division	87
Electronics Corporation of America, Photoswitch Division	5
Executive Services	17
Federal Products Corporation	1
Feedall Machine & Engineering Co.	93
Hamilton Automation, Inc.	106
Helipot Corporation, Division of Beckman Instruments, Inc.	105
Hewitt-Robins, Inc.	8
Hughes Research & Development Laboratories	94
Hunt, C. B. & Son, Inc.	91
Industrial Control Co.	104
International Business Machines	6, 7
Kendall, George H.	108
Lansing Stamping Co.	99
Magnetic Amplifiers, Inc.	13
Marsh Instrument Co.	109
Mechanical Handling Systems Inc.	19
Photoswitch Division, Electronics Corporation of America	5
Pioneer Engineering & Manufacturing Co., Inc.	85
Potter & Brumfield, Subsidiary of American Machine & Foundry Co.	116
Pratt & Whitney Division Niles-Bement-Pond Co.	14, 15
RapiDesign, Inc.	106
Scherr, George, Co., Inc.	114
Singer Manufacturing Co., The, Electrical Division Diehl Manufacturing Co.	101
Sterling Engineering Co., Subsidiary of American Machine & Foundry Co.	116
Streeter-Amet Co.	109
Strong Electric Corporation, The	99
Valvair Corporation	Inside Back Cover
Verson Allsteel Press Co.	Back Cover
Wean Equipment Corporation	Inside Front Cover
Weighing Components, Inc.	95
Wheeler Associates, Inc.	108